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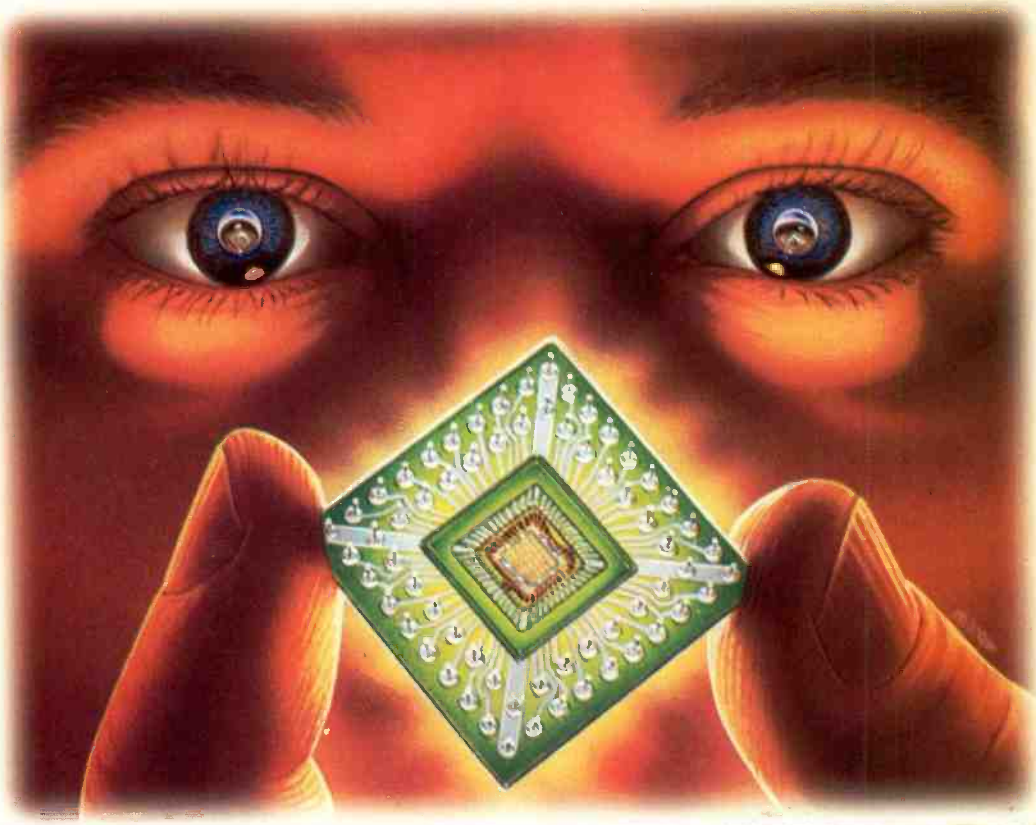

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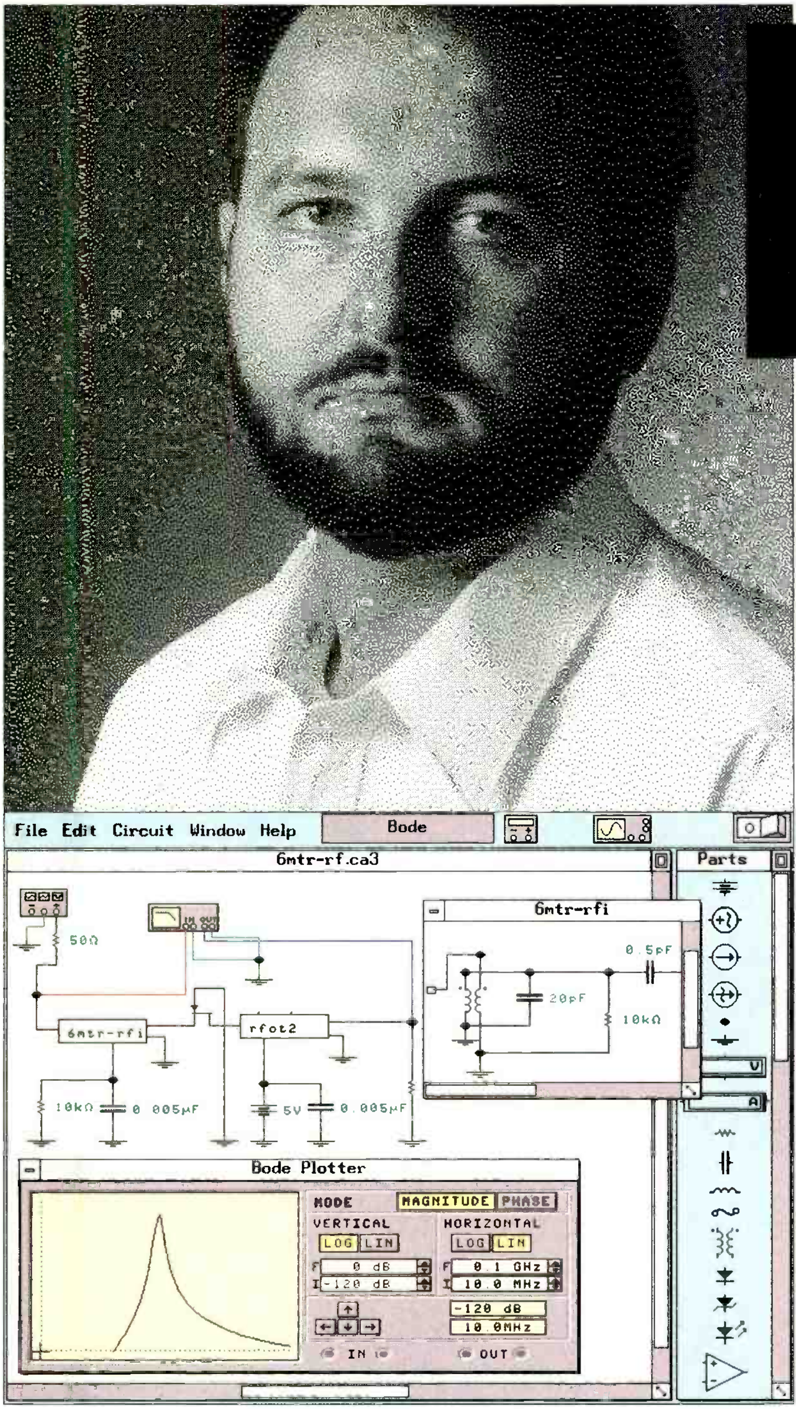

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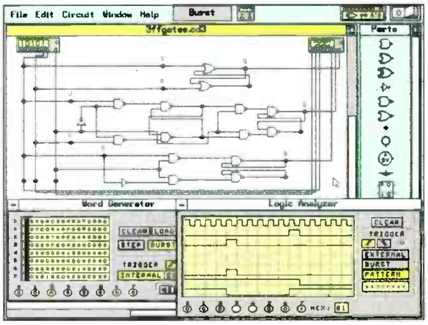

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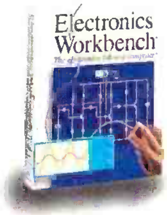

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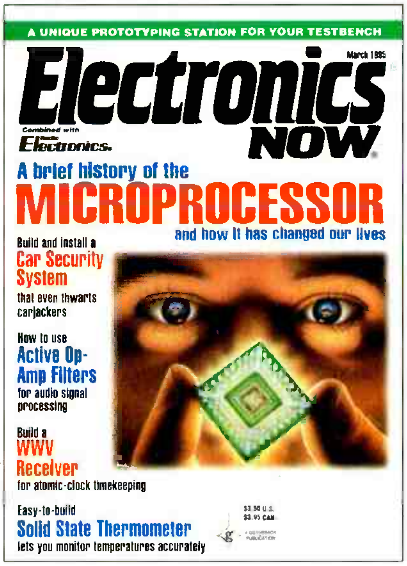

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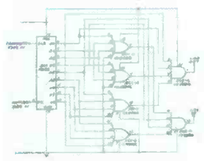

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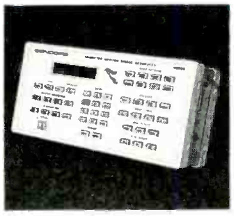

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WHAT'S NEWS

A review of the latest happenings in electronics.

Legal cable equipment sales

The Nebraska Supreme Court has upheld the right of independent vendors to sell cable converters and descramblers legally in Nebraska, and the National Consumer Cable Association (NCCA) has hailed the decision as "a major victory for the cable equipment manufacturing and distributing industry."

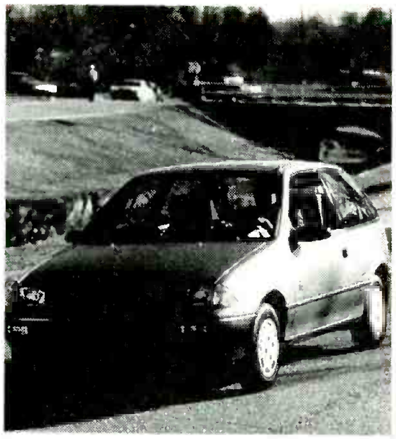
The Nebraska Supreme Court decision followed an appeal on a lower court decision in the case of illegal seizure of cable receiving equipment by the Omaha police. In November of 1988, the Omaha police confiscated and later destroyed 200 converters and descramblers owned by Imperial Trading Company. The District Court determined that the Omaha Police had wrongfully destroyed Imperial's property, but it only awarded the company a token $1 in damages.

After reviewing the lower court decision, the Nebraska Supreme Court ruled that Imperial must be properly compensated for its property losses for an amount equal to the market value of the equipment when it was seized. The Supreme Court also decided that the District Court made a mistake in finding that no lawful market for the equipment existed outside of the cable industry.

The NCCA sees the decision as an important step toward preserving the freedom of independent companies to manufacture and sell cable equipment. Moreover, it says the decision gives consumers the right to purchase and own their own cable receiving equipment rather than requiring them to rent it from cable companies.

Battery-powered cars tested

Twenty battery-powered "station cars," are being tested in a year-long Massachusetts Electric Vehicle Demonstration Project that was launched in April of 1994. The commuters selected to test drive the



ONE OF THE 20 ELECTRIC CARS being tested in Massachusetts over short commuting distances..

Force vehicles, Geo Metros modified by Solectria Corporation, Wilmington, Mass., offer high praise for their performance.

The commuters have been driving the electric cars, owned by the state-sponsored program, between their homes and nearby rapid transit stations. The drivers plug the batteries into electric outlets at the stations during the day and into household outlets when they arrive home. The chargers are built into the vehicles.

Karl Thidemann, Solecteria's marketing director, reports that all of the participating drivers have expressed satisfaction with the vehicles."No drivers have called to say they were stranded because of battery problems," he declared. Fifteen of the cars are powered by lead-acid batteries and five are powered by nickel-cadmium batteries.

The *Force* cars have direct-drive, brushless AC induction motors and an electronic motor controller with power-assisted regenerative brakes. The onboard chargers for the vehicles powered by lead-acid batteries are rated 1 kilowatt/120 volts AC, and those for the nickel-cadmium batteries are rated 2 kilowatts/208–240 volts AC. System power is 42 kilowatts. The test cars are equipped with many of the same standard safety and convenience features found in gasoline-powered cars.

The nickel-cadmium batteries in the five cars were produced by Saft America, Valdosta, GA. Jim Miller, Saft's project manager, said that these batteries function more efficiently in the bitter New England winter weather than lead-acid batteries. "At freezing temperatures, nickel-cadmium batteries lose only 5% of their capacity," he explained. "By contrast, lead-acid batteries can fall to 25 to 50% of their capacity."

Miller said the nickel-cadmium batteries give the test cars a range of 100 miles at 45 mph, while the lead-acid battery-powered have a range of only 60 miles at 45 mph.

Test Equipment sales to rebound

The communication test-equipment market will grow from $776 million in 1993 to $1.3 billion by the year 2000 according to a report entitled "U.S. Communications Test Equipment Market Sales,"published by Frost & Sullivan.

The report says that the market will expand at an 8% compound annual rate, and this expansion will be driven by growth in both the computer and telecommunications markets, as well as generally recovering capital goods sales following the economic recovery.

The report predicts that by the year 2000, dedicated communication and telecommunication test equipment will account for 53% of all communications test equipment sales. General purpose signal sources wil account for 15%, spectrum analyzers 11%, power meters 8%, and optical time-domain reflectometers 7%.

The largest growth will be in the

Continued on page 96

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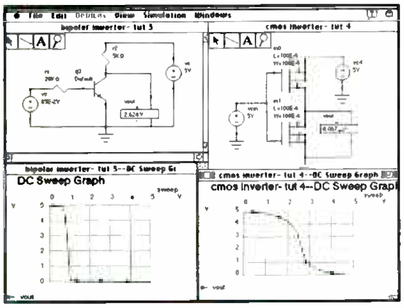

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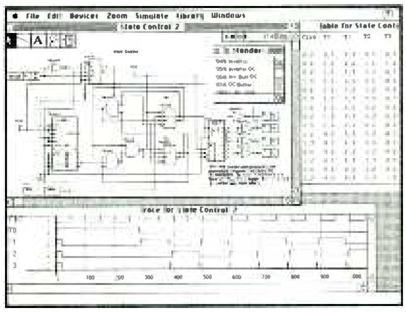

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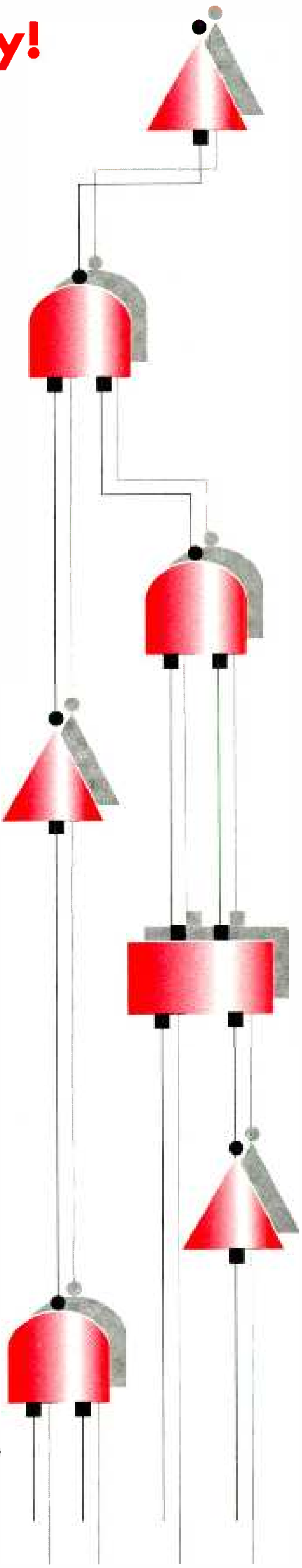

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VIDEO NEWS

What's new in the fast-changing video industry.

DAVID LACHENBRUCH

• Digital Video Disc Clash. Smoldering dispute over standards for the next-generation video-disc system has broken into the open, threatening exactly the standards battle the movie industry had hoped to avoid. As reported here (*Electronics Now*, January 1995), the major movie companies established a *de facto* group to select a digital video disc (DVD) standard offering 135 minutes of playing time on a five-inch disc with higher quality than current laser discs. The stated aim was to avoid a repetition of the Beta–VHS wars.

Now, Sony and Philips have gone public with their system, forcing the competitive Toshiba–Time Warner system into the spotlight as well. The Sony–Philips system, as announced, uses a single-sided, five-inch, high-density CD (HDCD) that is capable of storing 135 minutes of MPEG-2-quality video "together with multitracks of compressed digital audio and subtitling." The use of "variable transfer rate" for video of up to 10 megabytes per second (mbps) "means that the picture quality will be superior to that of current consumer video," the announcement said. The companies indicated that the system could be modified in order to achieve a "uniform standard." They said that their HDCD platform will be capable of storing 3.2 gigabytes (GB) of data—more than five times the data capacity of existing music CDs. They emphasized that the discs could be produced at "conventional manufacturing facilities with only minor modifications. That means, they said, that "production costs of the proposed new discs will be similar to that of conventional CDs, a major advantage for consumers and media manufacturers as well for the hardware and software industries."

Philips and Sony said that they are also discussing CD-ROM applications of their HDCD with Apple, Compaq, IBM, and Microsoft,

PHILIPS' LATEST GENERATION CD-i PLAYER is capable of playing full-motion-video movies and music videos recorded on five-inch digital video discs.

and are planning other multimedia uses, including interactive entertainment, video games, or "ultra-high sound quality audio." They also revealed specifications for a dual-layer version, developed in collaboration with 3M, which doubles disc capacity to about 7.4 GB. It uses two reflective layers within the disc, making possible double playing time without turning the disc over. Both the single- and dual-layer versions will be 1.2mm thick. The two companies said that standards will be finalized by mid-1995.

• The other system. The Philips–Sony announcement smoked out some details of the Toshiba–Time Warner proposal, which had been kept secret. A statement from Toshiba said that a prototype had already been developed and "mass production technology" was being completed for double-sided discs. The system has storage capacity of 4.8 GB per side, Toshiba said, adding that "we believe the number of sub-channels for dubbing soundtracks in different languages and the long recording time offered by our system ... satisfy the needs and expectations" of the movie industry. Toshiba said that "a storage capacity of 4.5 gigabytes is the minimum required to realize quality pictures and sound."

Toshiba's partner, Warner Home Video, said that the system should produce "radically improved pictures and audio quality at affordable prices on equipment that can sustain software upgrades," and added that, "We believe our manufacturing costs of discs should be comparable to those claimed by Sony and we have proven its manufacturability using existing CD equipment."

Warner Home Video's president, Warren Lieberfarb, was quoted in *Television Digest* as saying that manufacturability of discs was proven at Warner's CD plant, which he called the world's largest. "We do not believe Sony has proven the manufacturability or costing of its discs," he added. "We believe that both the yield and cycle time of the double-sided disc for these high-density formats is vastly superior to the 1.2mm proposal of Sony. We also do not think there is a material cost factor associated with our player achieving backward compatibility with CD.

Toshiba sources have suggested that the two-sided discs might accommodate two complete movies—one on each side, or possibly a movie on one side and a derivative video game or CD-ROM on the other. The larger data capacity presumably could accommodate five audio tracks and as many as 30 subtitle tracks.

• Video CD, too. The fanfare over DVD has left Video CD in a sort of limbo. That format, widely used in Japan for karaoke, stores 74 minutes of VHS-quality, full-motion video on a single five-inch disc. In the U.S., Philips is emphasizing Video CD as a significant add-on to its CD-i interactive system, although Video CD is the least interactive of its features, being designed to show linear movies. CD-i's main competitor, 3DO, is also featuring Video CD as an add-on, although currently only about 30

Continued on page 96

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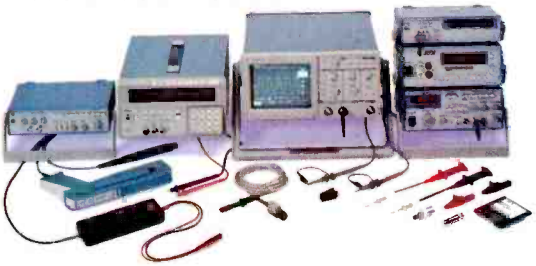

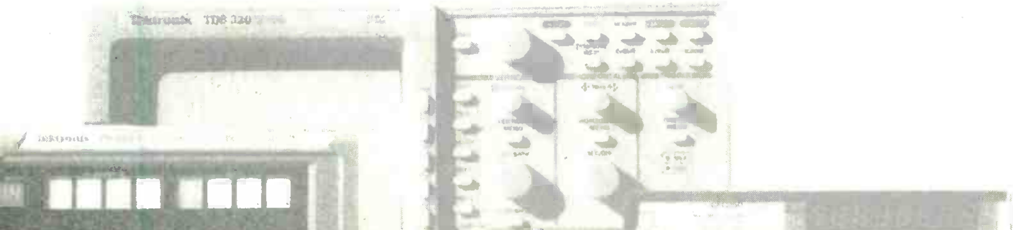

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Tektronix

Write to Q & A, Electronics Now, 500-B Bi-County Blvd., Farmingdale, NY 11735

LOW-POWER CLOCK

I'm building a circuit that needs a relatively slow clock to control it. The frequency of the clock has to have a range from about 0.1 to 2 Hz. I'm not looking for crystal accuracy. However, because the circuit must be battery powered and mounted in a remote location where it will be difficult to service, I do want a circuit that uses very little power. Do you have a simple off-the-shelf circuit I can use?—D. Katz, Great Neck, NY

The development of low-power components over the last several years has made the working life of batteries approach their shelf life in some circuits. This made the whole digital wristwatch industry possible. While it's not easy to steal clock pulses from a digital watch, there are some alternatives you can use for your application. You should find the circuits shown in Fig. 1 to be what you need.

The LM3909 is an LED flasher IC that is designed to oscillate at about the frequencies you're looking for. It can be set to one frequency or its frequency can be trimmer-adjustable. The 3909 will work reliably with a wide supply voltage range, and if you power it with a single alkaline D cell, the cell should last more than two years. Even though you need only clock pulses, remember that the 3909 can supply current pulses of up to 45 milliamperes at greater than 2 volts.

The clock output of the first circuit can be changed by changing the value of the capacitor, as indicated in the drawing. If you want to be able to adjust the clock frequency on the fly, use the second circuit and adjust the frequency with the trimmer shown in the schematic.

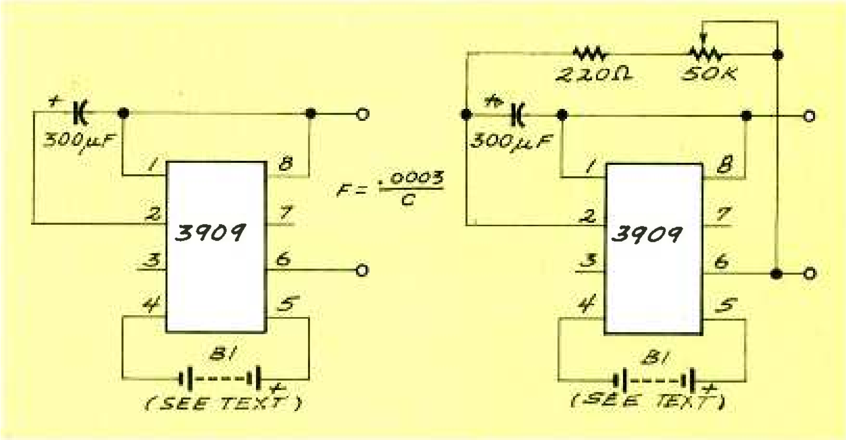

FIG. 1—THE LM3909 is an LED flasher IC that is designed to oscillate at low frequencies. The clock output of the first circuit can be changed by changing the value of the capacitor, and the second circuit lets you adjust the frequency with the trimmer.

DECELERATION DETECTOR

I'm looking for a way to detect deceleration in an automobile. Do you have any ideas about how this could be done? I'd like the device to be completely electronic because I think that would make it more reliable.—P. Pezzino, Cedar Grove, NJ

Detecting acceleration or deceleration always requires some kind of mechanical sensor. Even the accelerometers used in the most modern missiles and airplanes contain mechanical components.

This type of circuit can be broken into two basic parts. The first part detects changes in movement and converts those changes into an electronic signal. The second part measures the signal and displays it.

One technique is to measure the rotational speed of either the wheels or the drive shaft. How you do this depends on the particular car; front wheel drive cars don't have drive shafts in the traditional sense. In that case, you'd have to measure the speed of the wheels.

The basic procedure is to attach something to the moving part that can sense the rotational speed. This can be done optically or magnetically, but considering the harsh environment under a car, a magnetic pickup is the better choice. Magnetically coupled switches—such as the kind used in alarms to detect when a door or window opens—are readily available.

Another possibility is to use a device made specifically for the job, such as Analog Devices' ADXL50 solid-state accelerometer. The ADXL50 is essentially a capacitor with one stationary plate and one flexible plate. Acceleration can be determined by measuring the change in capacitance that occurs when the device is accelerated.

You could also try experimenting with your own accelerometer design. The resistance of conductive foam (the kind that protects static-sensitive CMOS ICs) changes as the foam is compressed. If you suspend a relatively heavy object between two pieces of this foam, changes in speed will cause the object to compress the foam in front when you decelerate, and compress the foam in back when you accelerate. By constantly measuring the minute changes in the resistance of the two pieces of foam, you'll have a signal that can tell you how much your car is accelerating or decelerating.

The circuit you need to convert the signal to a number on a dial depends on which approach you take to produce the signal in the first place. For example, the magnetic-pickup approach would require a counter circuit to count the change in rate of the number of switch closures per second.

MOTHERBOARD MISERY

I recently upgraded my computer by replacing its 8088-based motherboard with one based on an 80386. I reinstalled all my original expansion cards and peripherals, and while the computer turns on without any apparent problem, it won't recognize my hard drive. If I boot the computer from a floppy and try to access the hard drive, I get an "invalid drive" error message. I've checked all my cable connections and everything seems correct. Do you know what I'm doing wrong?—G. Fischer, New York, NY

The cause of the problem is the difference in the way the two microprocessors are designed to address the hard drives. To control the hard drive, the computer needs a collection of primitive routines that can control the cylinder and head selection, sector read and write, and so on.

In the design of an 8088-based computer, these routines were in the firmware on the hard drive controller card. In machines based on 80286 and later microprocessors, these routines were incorporated in the BIOS (basic input output system), usually contained in one or more EPROMs on the motherboard, and the computer's setup program stored the hard-drive specifications in permanent (battery-backed) CMOS memory.

If you use the hard drive and controller from an 8088 in a later computer, the hard drive must be accessed with the controlling firmware on the controller card. This means you have to tell the CMOS setup program that there are no hard drives installed in the computer. If you set the drive types in the computer's CMOS setup memory, all software, including DOS, will try to access the hard drive using the primitive routines in the computer's BIOS. This will result in a failure, and an "invalid drive" message.

The way to correct this problem is to run the setup program again and tell the computer that there are no hard drives installed. This will allow the controller card's firmware to address the drives and everything will work correctly. Ω

LETTERS

Write to Letters, Electronics Now, 500-B Bi-County Blvd., Farmingdale, NY 11735

REPRINTED PROGRAM

In the article, "Programmable Sinewave Generator" (Electronics Now, January 1995), program Listing 1 (pages 46 and 47) was printed on a background that was too dark and so the listing was hard to read. A clearer version is reprinted here.—Editor

WRONG ADDRESS

In the article ,"Power Controller" (Electronics Now, January 1995), on page 60 the address of Richard L. Roan is incorrect. It is P.O. Box 752, Saluda, VA. 23149.—Editor

SWEEP/FUNCTION CORRECTIONS

The following corrections should be made to the article "Sweep/Function Generator," Electronics Now, December 1994, page 53:

Fig. 1—(1) Ground the negative side of capacitor C1 and the positive sides sides of capacitors C2 and C3. (2) Connect the collector of Q1 to the junction of R13, D4, and C9. (3) Connect the wiper lead of trimmer R22 to the "+" side of C10. (4) Ground the junction of resistors R37 and R40 and the collector of Q4, (5) Indicate that the − 15-volt supply for IC1 is obtained from the anode of D8.

Fig. 4—(1) Diameters of three pilot holes (lowest row) should be 0.062, *not* 0.62 inch, (2) Diameter of first 0.375-inch hole (lower left) should be 0.234, *not* 0.375 inch, Diameters of two holes, right end of row, should be 0.375, *not* 0.234 inch.

Fig. 5—(1) Switch S2 pinout: connect pin 6 to the R27 wiper. (2) Switch S5 pinout: jumper pin 2 to pin 5 (R31) and jumper pin 1 to pin 3 (1, 3).

Page 56 "Circuit description:" In column 3, lines 17 and 18, change R11 to R12 and R15 to R16; line 24, change R11 to R30. Refer to the corrected schematic, Fig. 1.

Page 56 "Power supply:" The AC input is supplied by a 120-volt AC to 15- to 18-volt AC wall-outlet transformer, *not* a DC wall-outlet adapter. (Make this change in the parts list, page 60.)

Page 59 "Test and checkout:" In column 3, line 3, change R6 to R7; line 7, change R5 to R6.—Editor

RETHINKING THE RESISTOR CUBE

As a retired electrical engineer, I enjoy the diversity of topics covered in *Electronics Now*. The article "Solving the Resistor Cube" (December 1994) triggered my memories of the early 1930s when I first encountered the problem.

I agree that it's a good teaching aid, but please let's not give the upcoming generation of young engineers and technicians the impression that the solution is complex and difficult—four pages of diagrams and calculations—shame!

The author says that this is a beautiful example of "electronic symmetry" but he fails to take full advantage of that fact.

I didn't have a pencil and paper handy at the time, but by just look-

LISTING 1

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*****************************************************************************
DECLARE SUB FREQUENCY (L1, L2, FLAG)        '**** Frequency input routine
DECLARE SUB FREQCLR (L1, L2)                '**** Clear frequency entries
DECLARE SUB LOAD ()                         '**** Parallel-serial data convert
DECLARE SUB ERMSG (L1, L2)                  '**** Error messages
DECLARE SUB DSPLY ()                        '**** Display screen

COMMON SHARED FMT$, N1&, N2&, K, DP, PORT$, MSG$(), L1, L2
DIM Z AS STRING * 1: DIM MSG$(20)
FMT$ = "###,###,###,###.####": Clk = 32000283: K = (2 ^ 32 / Clk)

'****************************************************************************
'       To select NCO parallel printer remove the (') "comment symbol"
'       in front of the appropriate program line.
'       PRINTER PORT "LPT2" will be selected by the following:

     'port$ = "LPT1": dp = &H3BC      '*** LPT1 DATA PORT ADDRESS
      PORT$ = "LPT2": DP = &H378      '*** LPT2 DATA PORT ADDRESS
     'port$ = "LPT3": dp = &H278      '*** LPT3 DATA PORT ADDRESS
'****************************************************************************
'********** (Message iist) **********
MSG$(1) = "          Input range is from 0.00Hz to 10,000,000.00Hz         "
MSG$(2) = "       Program accepts numerals and a single decimal point      "
MSG$(3) = STRING$(64, " "): MSG$(4) = STRING$(21, " ")
MSG$(5) = "Last input not transferred to NCO": MSG$(6) = STRING$(50, " ")
MSG$(7) = "PSG output signal OFF"
MSG$(8) = "PROGRAMMABLE SINEWAVE GENERATOR CONTROL SCREEN"
MSG$(9) = "PSG printer port is " + PORT$ + ".  "
MSG$(10) = PORT$ + " uses I/O port " + HEX$(DP) + "HEX"
MSG$(11) = "COPYRIGHT 5/94 by R.J. PORTUGAL, NORTH HAVEN, CT. 06473, U.S.A."

COLOR 15, 1: CLS : CALL DSPLY: N1& = 0: N2& = 0: CALL LOAD
'----------------------------------------------------------------------------
DO: K$ = INKEY$                                 '*** Main Program
IF LEN(K$) = 2 THEN         'check keyboard entry for 2 character scan code
      IF ASC(RIGHT$(K$, 1)) = 59 THEN CALL FREQUENCY(5, 6, 1)      '**** [F1]
      IF ASC(RIGHT$(K$, 1)) = 60 THEN CALL FREQUENCY(8, 9, 2)      '**** [F2]
      IF ASC(RIGHT$(K$, 1)) = 61 THEN                              '**** [F3]
        N1& = 0: N2& = 0: CALL LOAD
        CALL FREQCLR(5, 6): CALL FREQCLR(8, 9)
      END IF
      IF ASC(RIGHT$(K$, 1)) = 62 THEN CALL LOAD       '*** [F4]
      IF ASC(RIGHT$(K$, 1)) = 63 THEN                 '*** [F5]
COLOR 6 + 16, 7: OUT DP, 1 + 8                        '*** nco clock off
LOCATE 15, 40 - LEN(MSG$(7)) / 2: PRINT MSG$(7)       '*** Prints message
DO: K$ = INKEY$: LOOP UNTIL K$ = CHR$(0) + CHR$(63)   '*** Wait for "F5" key
COLOR 15, 1: LOCATE 15, 40 - LEN(MSG$(4)) / 2: PRINT MSG$(4)
OUT DP, 1                                             '*** Turns NCO clock ON
      END IF
      IF ASC(RIGHT$(K$, 1)) = 68 THEN GOTO endp       '*** [F6]
END IF
LOOP
endp: COLOR 7, 0: CLS
END                 'xxxx END PROGRAM xxxxx END PROGRAM xxxxx END PROGRAM
'----------------------------------------------------------------------------
```

ing at the cube it was apparent to me that the battery current (I) entering one corner, the "in" junction will divide equally three ways—the three resistors at that junction will carry (I/3) current each. The three resistors on the "out" junction also will carry (I/3) each, and all other resistors will carry half that amount because the (I/3) current divides equally between them (as a result of symmetry).

The total voltage drop across the cube will equal the sum of voltage drop across the three resistors comprising a pathway—*any pathway*—from the "in" junction to the "out" junction. Thus, the voltage drops of the first "in" resistor as well as the last "out" resistor are R(I/3) each, and the resistor between is R(I/6).

Then I called on my grandson (who is in the fifth-grade and is is a whiz at adding fractions in his head) to do the calculations. He said that $\frac{1}{3} + \frac{1}{3} + \frac{1}{6} = \frac{5}{6}$, so the cube voltage (E) is R($\frac{5}{6}$I). The net cube "in" to "out" resistance is E/R = ($\frac{5}{6}$)R.

Thus, I really didn't need my pencil and paper after all. A bit of advice here: Be sure to use a negative sign in summing if any pathway in a similar kind of problem includes a resistor in which current flows in the opposite direction.

I appreciated the opportunity to dig this little gem out from my dusty old memory files.

E.D. SISSON
Columbus, OH
Ω

```
SUB DSPLY
COLOR 15, 10: LOCATE 2, 40 - LEN(MSG$(8)) / 2: PRINT MSG$(8)
COLOR 15, 1: LOCATE 5, 1
PRINT "        [F1]        Enter Frequency 1                          Hz"
PRINT "                    (0.00 to 10,000,000.00Hz                   usec"
PRINT
PRINT "        [F2]        Enter Frequency 2                          Hz"
PRINT "                    (0.00 to 10,000,000.00Hz                   usec"
PRINT
PRINT "        [F3]        Clear Frequency 1 and 2 to zero": LOCATE 19, 1
PRINT "        [F4]  Load NCO                    [F5]  Start/Stop PSG output"
PRINT
PRINT "                          [F10]   End program-return to DOS"
COLOR 15, 10
LOCATE 23, 40 - (LEN(MSG$(9)) + LEN(MSG$(10))) / 2: PRINT MSG$(9) + MSG$(10)
COLOR 7, 9: LOCATE 25, 40 - LEN(MSG$(11)) / 2: PRINT MSG$(11); : COLOR 15, 1
END SUB

SUB ERMSG (L1, L2)                     '*** Displays 2 line error message
CALL FREQCLR(L1, L2)
COLOR 14, 4:  FOR i = 14 TO 15:       LOCATE i, 9: PRINT MSG$(i - 13); : NEXT i
SLEEP 4: COLOR 15, 1: FOR i = 14 TO 16: LOCATE i, 9: PRINT MSG$(3): NEXT i
END SUB

SUB FREQCLR (L1, L2)          '*** Clears control panel F1 & F2 display areas
COLOR 14, 4: LOCATE L1, 45: PRINT MSG$(4): LOCATE L2, 45: PRINT MSG$(4)
END SUB

SUB FREQUENCY (L1, L2, flg)                  '*** F1 & F2 input routine
COLOR 14, 4: CALL FREQCLR(L1, L2): LOCATE L1, 45: LINE INPUT f$
IF VAL(f$) > 10000000 OR VAL(f$) < 0 THEN CALL ERMSG(L1, L2): GOTO esub
dpf = 0
     FOR i = 1 TO LEN(f$)          '*** F1/2 numeral & multiple decimal point
     x$ = MID$(f$, i, 1)           '*** check
      IF x$ = "." AND dpf = 0 THEN : dpf = 1: GOTO x
      IF x$ = "." AND dpf = 1 THEN CALL ERMSG(L1, L2): GOTO esub
      IF ASC(x$) < 48 OR ASC(x$) > 57 THEN CALL ERMSG(L1, L2): GOTO esub
x:   NEXT i
      f = VAL(f$): LOCATE L1, 45: PRINT USING FMT$; f;  '*** prints freq
LOCATE L2, 45
IF f <> 0 THEN PRINT USING FMT$; 1000000 / f;        '*** period of F1 or F2
IF flg = 1 THEN N1& = K * f               '*** Converts F1 or F2 to a 32bit word
IF flg = 2 THEN N2& = K * f               '*** compatible with NCO input specs
COLOR 22, 7: LOCATE 16, 40 - LEN(MSG$(5)) / 2: PRINT MSG$(5): COLOR 15, 1
esub:
END SUB

SUB LOAD      '*** Converts F1&2 into serial format & shifts them into NCO
FOR j = 3 TO 0 STEP -1: FOR x = 7 TO 0 STEP -1    '***** Xfer first 32 bits
      IF (PEEK(VARPTR(N2&) + j) AND 2 ^ x) > 0 THEN dt = 2 ELSE dt = 0
OUT DP, dt + 4: OUT DP, 1 + dt + 4          '*** Serial data and shift
NEXT x: NEXT j                              '*** pulse generator
FOR j = 3 TO 0 STEP -1: FOR x = 7 TO 0 STEP -1    '***** Xfer second 32 bits
      IF (PEEK(VARPTR(N1&) + j) AND 2 ^ x) > 0 THEN dt = 2 ELSE dt = 0
OUT DP, dt + 4 + 16: OUT DP, 1 + dt + 4 + 16      '*** Serial data and shift
NEXT x: NEXT j                                    '*** pulse generator
      OUT DP, 1 + 16                              '*** Xfers new F1&2 to NCO
COLOR 15, 1
LOCATE 16, 10: PRINT MSG$(6)
END SUB
```

EQUIPMENT REPORTS

Sencore CM125 Computer Monitor Signal Generator

If you regularly test computer monitors, the Sencore CM125 computer monitor signal generator will make your work easier and you'll do it faster.

CIRCLE 15 ON FREE INFORMATION CARD

The need for specialized computer monitor test equipment has increased dramatically in the last decade, not only in repair shops but at the factories where they are made. Monitor video bandwidth has expanded as a result of the increases in horizontal scan frequency and the display resolution.

Computer monitors with cathode ray tubes are among the most expensive personal computer peripherals, and they are those most likely to fail because of their high-voltage power requirements and the complexity of their scanning circuitry. With the price and performance of monitors increasing, they are no longer disposable components.

The CM125 "Pix Pak" computer monitor signal generator from Sencore is intended for testing, troubleshooting, evaluating, and comparing all brands of computer monitors and projectors on the shop test bench, at the burn-in rack, or in the field.

The CM125 offers a 125-MHz video bandwidth and pixel resolution of 2048 × 2048. The portable instrument is output protected to prevent it from being damaged by defective computer monitors under test. It weighs less than five pounds and has a price tag of $2,995. (Sencore, 3200 Sencore Drive, Sioux Falls, SD 57107, 605-339-0100, 1-800-SENCORE.)

How is it organized?

The CM125 is packaged in a book-sized rectangular case with an array of resilient pushbutton controls and a liquid-crystal digital display on its front panel. Some of the pushbuttons contain LED function indicators. The pushbuttons on the left side are organized as TYPE, INTERLACE, MONITOR PARAMETERS, BLANKING TIME and POWER.

The middle pushbuttons are ENTRY AND MEMORY and those on the right side are VIDEO PATTERNS, POLARITY, VIDEO OUTPUT, SYNC OUTPUT, and SYNC ADDER. The two-line LCD readout shows the scan frequency, pixel resolution, and blanking timing of signals generated by the CM125.

The output terminal for phase-locking accessories, a 15-pin D-type connector, and sync and video outputs for driving the monitor under test are on the right side. An RS-232 connector for connecting a personal computer to automate test functions and an AC power jack are on the left side. A fold-down handle on top makes the instrument easy to carry, and fold-out bails on the back permit it to be positioned at different angles.

The first step in setting signal parameters is to select one of the three pushbuttons designated for the three different kinds of monitors—digital, analog, or ECL (emitter-coupled logic). A digital monitor receives TTL logic signals and can display a limited number of colors while an analog monitor receives a 0.714-volt signal and can display an infinite number of colors.

An ECL monitor, a form of digital monitor that receives a signal between −1.6 and −0.9 volts, can display a limited number of shades of gray. A fourth pushbutton turns the interlace scan on and off. Most computer monitors in service today are noninterlaced analog units.

The next step is to select the monitor parameters including horizontal sync frequency, horizontal pixel resolution, vertical synch frequency, and vertical pixel resolution. After a function is selected, numerical values are entered from a keypad. Horizontal frequency can be in the range of 10 to 250 kHz, vertical frequency can be from 10 to 250 Hz, and both horizontal and vertical pixels can range from 80 to 2048. The LCD normally displays the numerical value of those four settings.

Next, four blanking parameters must be set: front porch time, sync time, back porch time, and active video time. The combination of front porch, back porch, and sync times makes up the blanking time. That value added to the active video time equals the total scan time.

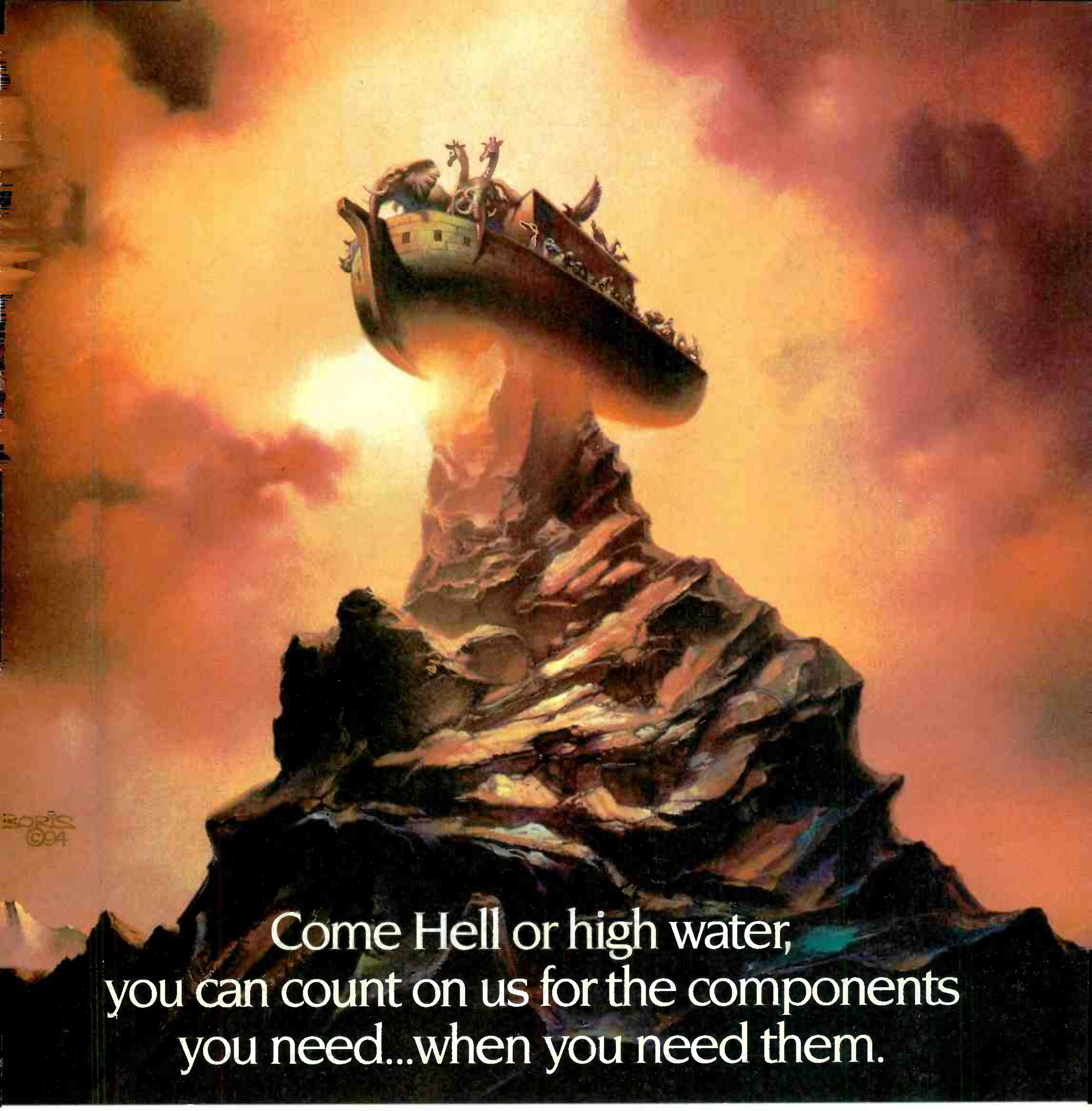
Four pushbuttons set the polarity of the video, horizontal sync, vertical sync, and blanking signals. Other pushbuttons activate red, green, blue (R, G, B), and (intensity (I) lines. Only digital monitors have an I output. Other controls turn the horizontal, vertical, and composite sync signals on and off, and add composite sync to the video.

The process of entering all parameters for certain monitors can be time-consuming, but the CM125 can test most popular monitors conveniently with the 43 factory setups stored permanently in memory. Moreover, the other 57 custom settings can also be stored.

Available test patterns

After the CM125 is set for a specific monitor, a video pattern must be selected from the seven available patterns: raster, circle/cross, color bars, staircase, windows, multi-

Continued on page 33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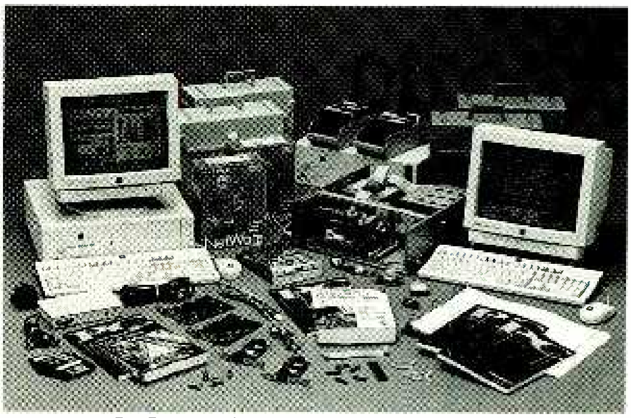
PC TRAINING KITS. The Tech-Knowledge system is intended for teaching personal computer servicing, troubleshooting, and networking. Offered by Heathkit Educational Systems, it is now available in a single, comprehensive package, the EZS-400 for PC servicing, troubleshooting, and networking, or as three separate complementary units. They are the EZS-401 for PC Servicing, the EZS-402 for PC Troubleshooting, and the EZS-403 for PC local area networking.

Each training unit is complete with hardware, software, and course materials. The system is based on an IBM-compatible personal computer with an Intel 486 microprocessor. The PC can be upgraded by replacing the 486 processor with an Intel P24T Pentium processor.

The personal computer servicing course covers substantially all a student needs to know about servicing, maintaining, upgrading, and optimizing a personal computer. Hands-on exercises reinforce each topic covered in the textbook.

Students will be able to study the operation of various computer circuits with the guidance offered by manufacturer's technical manuals and schematics. That knowledge can be applied to troubleshooting personal computers with the aid of diagnostic software and standard test equipment.



CIRCLE 20 ON FREE INFORMATION CARD

Instruction is also given in specifying, installing, and troubleshooting local area networks. The course also explains how to install and configure modems and communications software. It includes Microsoft Windows for Workgroups Software and Novell Personal NetWare.

The courses include seven of Heathkit's fault insertion and removal modules (FIRMs), circuit boards with DIP switches that permit the simulation of circuit faults without altering the training computer or its peripherals. Each course includes a student text book, student work book, instructor's guide and course experiment parts packages.

The complete EZS-400 package includes two Zenith Data Systems computer trainers with multi-frequency color monitors, 210 Mbyte hard-disk drives and PS/2 compatible keyboard and mice. If purchased as separate units, the EZS-401 and EZS-402 packages each contain one computer and monitor. The EZS-403 package includes two computers and two monitors.

The pricing of the instruction packages is as follows: EZS-400—$7495, EZS-401 and EZS-402—$2495, and EZS-403 — $5995.

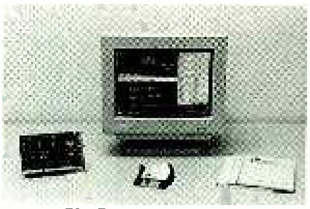
Heathkit Educational Systems
455 Riverview Drive
Benton Harbor, MI 49022

DSP DEVELOPMENT SYSTEM. The digital signal processing development system from Domain Technologies is an integrated software development platform for the Texas Instrument TMS230C31 floating-point, digital-signal processor (DSP). The system is intended for developing, testing, debugging, and running DSP software. It includes an assembler, a symbolic debugger, and a target card.

Applications for the system include algorithm development, data acquisition, instrumentation, telecommunications, and signal processing. The PC plug-in card contains a TMS320C31 IC, static memory, an analog input/output port, and two independent personal computer interfaces.

The analog I/O unit includes an analog interface IC with 14-bit resolution and two RCA jacks. The interface IC can sample up to 19,200 samples per second, and it contains filters for anti-aliasing and smoothing.

The debugger screen interface is symbolic and visual. Each of the DSP's resources is displayed in its own window. A built-in assembler/disassembler can monitor and edit the application routine. Data can be displayed in one of seven modes, and up to 128 breakpoints can be set simultaneously. Programs written in C can be debugged at the source level.



CIRCLE 21 ON FREE INFORMATION CARD

The floating-point macro assembler is fully compatible with the TMS320C3x instruction set. It supports macro capabilities, conditional assembly, symbol table generation, source-level information, and full error diagnostics.

The DSP Development System is priced at $600.

Domain Technologies, Inc.
1700 Alma Drive #245
Plano, TX 75075
Phone: 214-895-7593
Fax: 214-985-8579
E-mail: domain@metronet.com

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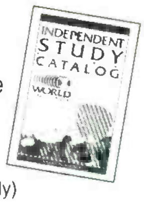

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CONSTANT-CURRENT POWER SUPPLY. The Model 930 constant-current power supply from Calex has a temperature coefficient of 0.001%/°C and an output impedance of 10 megohms. Its power requirements are +12 to +32 volts. It is sold with a mounting kit that includes a potentiometer for setting constant current from 0 to +50 milliamperes.

CIRCLE 22 ON FREE INFORMATION CARD

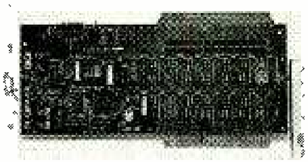
The Model 930 can function as a bridge excitation supply. By adding a 10,000-ohm resistor, the supply becomes a stable 100-microampere current source for resistance-temperature sensors (RTD).

The Model 930 is priced at $115.

Calex Manufacturing Company, Inc.
2401 Stanwell Drive
Concord, CA 94520
Phone: 800-542-3355
Fax: 510-687-3333

SMART EISA EXTENDER CARD. The EISA-EXT EISA extender card from ICS Electronics allows EISA and ISA bus add-on cards for IBM or compatible personal computers to be tested and debugged in the PC card cage without powering the computer up and down to change cards.

The EISA-EXT card protects the computer against power-supply overloads caused by the card under test. Solid-state switches on all signal lines permit the card under test to be



CIRCLE 23 ON FREE INFORMATION CARD

changed while the computer is running. The card can be operated either by a switch on the card or by I/O commands from the test program.

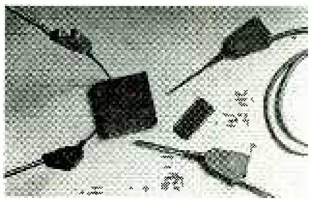
The turn-on sequence applies power and signals to the card under test in a sequence that avoids any conflict with the computer bus signals. The card continuously monitors the power lines to the card under test and shuts down all power and signals if an overcurrent condition is detected. Light-emitting diodes on the card indicate power, signal connection, and overcurrent.

The EISA-EXT card, including a disk with sample control programs and integrating software for Windows, is priced at $595.

ICS Electronics Corporation
473 Los Coches Street
Milpitas, CA 95035
Phone: 408-263-5896

ULTRA-THIN TEST CLIPS. The Ultra-Thin Micrograbber series test clips from ITT Pomona are intended for microcircuit packages with finely spaced pins with up to 0.050 inch pitch. Narrow bodies that measure 0.12 inches permit close stacking of the clips.

The clip wiring is flexible to permit easy access from



CIRCLE 24 ON FREE INFORMATION CARD

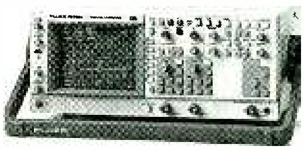
different angles. Serrated surfaces on the plunger and finger tabs improve the holding ability of the test clips. The contact pincers open to 0.024 inch to grip the leads.

Two styles of test clips are available: single-ended and double ended. Single-ended clips with 40-inch lead wires are available in 10 colors. Double-ended clips (contacts on both ends) are available with black or red lead wires in 10-, 20-, or 30-inch lengths.

Ultra-Thin Micrograbber test clips are priced from $4.50 each.

ITT Pomona Electronics
1500 East Ninth Street
Pomona, CA 91766
Phone: 909-469-2928
Fax: 909-629-3317

TWO-CHANNEL DIGITAL STORAGE OSCILLOSCOPE. The new PM 3380A from Fluke is a two-channel digital storage oscilloscope (DSO) with autoranging. The PM 3380 can automatically scale to signals. Autoranging continuously adjusts the timebase, and attenuators keep the signal on-screen during signal changes or while a circuit is being probed.



CIRCLE 25 ON FREE INFORMATION CARD

Special probes included with the PM 3380A have a user-programmable command switch near the tip. The switch, in conjunction with autoranging, allows the user to probe a circuit without having to make frequent changes on the control panel.

The probe-tip switch speeds up measurement by allowing the user to switch between DSO and analog modes, recall stored setups, perform voltage and time measurements, and initiate an auto-set routine.

The PM 3380A can display the waveform on the external trigger input. It also has an over-sampling peak-detector, which reveals spikes and high-frequency noise at all time-base speeds. Other features include closed-case calibration with built-in voltage and time standards, TV line and field triggering, a built-in video line counter and standard computer. An RS-232-C interface permits printing out results.

The PM 3380A two-channel, autoranging digital oscilloscope is priced at $3495.

Fluke Corporation
P. O. Box 9090
Everett, WA 98206
Phone: 800-44-FLUKE
Fax: 206-356-5116

DEOXIDIZER/CLEANER/PRESERVATIVE TREATMENT. DeoxIT from Caig Laboratories is a fast-acting, one-step deoxidizing solution for cleaning, preserving, lubricating, and enhancing conductivity of metal connectors and contacts on products such as switches, potentiometers, and relays.

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CIRCLE 26 ON FREE INFORMATION CARD

TekMeter™ can show you the answer before you even know the question.

TekMeter™ is the new handheld instrument from Tektronix that combines the functions of a DMM and an oscilloscope. It's practically "auto everything." Which in the service business means you'll get the answers you need faster than ever before.

It's easy. Just connect the probes. TekMeter finds the signal then makes the correct scope or DMM settings to display voltage, current or waveforms in the most meaningful way. What's more, your hands remain free to probe more accurately and safely. Especially in small places.

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Weighing barely 2 pounds, TekMeter includes a host of features like cursors and spike detect that improve your ability to maintain and troubleshoot a wide range of equipment. TekMeter can even capture incoming line voltage spikes and sags, measure voltage and current simultaneously, compute true power, and more. All automatically. For as little as $875.*

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CIRCLE 92 ON FREE INFORMATION CARD

World's first wireless home theater system makes professional-quality surround sound affordable...

Now you can add surround sound to your home entertainment lineup with the amazing new Chase Technologies decoder that works with your existing stereo and an assortment of wired and wireless speakers.

by John Lindner

Let's face it. As much fun as renting a video can be, it's just not the same as seeing a movie in a theater. I remember the first time I saw *Jurassic Park*—I nearly jumped out of my seat when the dinosaurs roared. One of the reasons movies seem so real is because surround sound makes it seem like you're actually there when events are happening. Now there's an incredible new device that lets you use your stereo receiver to get that same surround sound in your home.

The secret of surround sound

Surround sound has become the rage of the '90s because it adds depth and realism to stereo sound, giving you the home theater experience. In short, it makes you feel like you are actually at a concert a theater.

To get surround sound, some people have tried simply adding additional speakers to their home entertainment lineup. But it takes more than additional speakers to get surround sound; there needs to be a way of separating the original signal into distinct channels so that you're not just duplicating the same sounds and broadcasting them from different areas of the room.

The new Chase Technologies HTS-1 surround sound decoder does just that, and in a revolutionary way that rivals the best Dolby Pro-Logic and THX systems available. The HTS-1 provides five channels of sound from any two-channel stereo source.

The HTS-1 works with a variety of speakers. In the front, you can use your existing stereo speakers. For the rear, choose from inexpensive wired speakers, high-quality wireless speakers, or even an audiophile-quality wireless satellite subwoofer system. The HTS-1 also gives you the ability to add a powered center channel speaker (instead of using your TV's built-in speaker).

The secret's in the signal. To get surround sound, you need to do more than simply add extra speakers. There needs to be a way of separating the signal from the musical score or movie soundtrack into distinct channel for each speaker. The new Chase Technologies HTS-1 surround sound decoder does just that, and in a revolutionary way that rivals the best Dolby Pro-Logic and THX systems available today.

Wins over critics. In the September 1994 issue of "High Performance Review," noted audio critic Daniel Kumin said "the HTS-1 can do quite a job of recreating a 3D theatrical experience...surround effects emanated with satisfying fullness...sound was clean at any level...with quite involving and natural sound ambience."

The new HTS-1 decoder won the *Design and Engineering Award* at the Consumer Electronics Show for being one of the best and most innovative new products.

Plus, John Sunier, a leading authority on surround sound and producer of *Audiophile Audition*, a nationally syndicated radio program for audio enthusiasts, says, "...the new Chase HTS-1, when used to decode the hidden ambience in all musical recordings, definitely outperforms all the Dolby and THX processors (which could cost you up to $3,000)...I am impressed!"

Decoding breakthrough. Last year, audio industry veteran Bob Rapoport invented a new five-channel "passive" circuit for decoding the *Dolby Surround*™ signals in every stereo, videotape or laserdisc. This passive method is superior to active decoders such as Dolby and THX because it requires no AC current to decode. As a result, you experience more clarity, more detail, and a greater sense of space. Plus, you won't experience the noise or distortion which can occur with active decoding methods. You don't need any extra amps! Just connect the HTS-1 to your stereo, add your speakers, and you'll experience the magic of home theater at a fraction of the cost of other systems.

Five channel options. The HTS-1 decoder can be used with two, three, four or five channels of amplification, making it the most cost effective method for upgrading your stereo system to full home theater performance on the market. Best of all, the HTS-1 works with a variety of hard wired and wireless speakers.

In the front, most people use wired stereo speakers. Use your existing stereo's speakers or use one of a variety of wired speakers. Comtrad also offers the Chase Dialog center channel speaker. If your front speakers are more than eight feet apart, adding a center channel speaker will help keep voices and sound effects centered on the screen for stunning localization and clarity. The Dialog is self powered and video shielded to prevent interference with your television set.

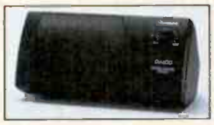
The Chase HTS-1 decoder is the most cost-effective method for upgrading an existing stereo system to full home theater performance on the market.

The new Chase Technologies HTS-1 surround sound decoder gives you the option of using either traditional wired speakers like the Chase ELF-1s, or using wireless speakers or a wireless satellite subwoofer system for additional convenience and enhanced sound quality.

Speaker Options

Wired Speaker Options

Front Speakers: The Chase HTS-1 surround sound decoder can utilize your existing stereo speakers, or any of a variety of wired speakers available through Comtrad or your local electronics dealer.



Center channel speaker. If the front speakers are more than eight feet apart, adding a center channel speaker will keep voice cues centered on the screen. We offer the Dialog. It is self-powered and video shielded to prevent interference with TVs. Dialog $75 $8 S&H

Rear channel speakers. We recommend the quality Chase ELF-1 in either white or black for inexpensive rear channel speakers. Mount them with the enclosed color-matched mounting brackets or flush mount them on the wall. ELF-1 .... $99/pair $10 S&H

Wireless Speaker Options

Rear channel speakers. Recoton W440 wireless speakers are the perfect option for people who want quality stereo rear channel speakers without having to run speaker wire. Their two-inch tweeters and four-inch woofers deliver 10 watts per channel—clear, strong stereo fill sound. The speakers work up to 150 feet from the transmitter without loss of sound quality. TX1000 transmitter (works unlimited speakers) ..... $69 $7 S&H
W440 wireless speaker (each) .... $89 $9 S&H

Get the Chase HTS-1 half off ($49) when you buy the W440 speaker system!

Rear channel speakers. For true audiophile-quality rear channel speakers, we offer the Recoton wireless satellite subwoofer system. This first-of-its-kind system combines a 10-inch rear-firing subwoofer with a pair of 25-watt satellite speakers. The subwoofer provides that distinctive "low-end punch" that you feel in movie theaters, while the satellites are designed to coincide with surround sound processor specifications balance perfectly with the front speakers. WHT470 transmitter ... $69 $7 S&H
WHT421 wireless 50-watt subwoofer .... $299 $24 S&H
WHT462 pair of wireless 25-watt satellite speakers $329 $24 S&H

Get the Chase HTS-1 FREE when you buy the satellite subwoofer system!

Wireless freedom. When it comes to rear speakers, you can again choose standard wired speakers like the Chase ELF-1s. But if you want to avoid the hassle of running speaker wire up and down walls, behind furniture, and under carpet, you can add the freedom and convenience of wireless speakers.

Recoton wireless speakers utilize a transmitter which broadcasts sound signals up to 150 feet through walls, floors and ceilings. The speakers can be placed anywhere; they plug into a standard electric outlet. This eliminates the need to have wires running from the stereo to the speakers, which can be a nuisance with surround sound since the rear speakers are often elevated or wall mounted.

Affordable option. Recoton's W440 speakers allow you to add wireless rear channel speakers without compromising the sound quality that wired speakers deliver. Each self-amplified speaker contains a two-inch tweeter and four-inch woofer. They deliver 10 watts per channel for strong, clear fill sound. Their compact design (9" high x 6" wide x 5.5" long), make them the perfect bookshelf-sized companion to your home entertainment set up.

Audiophile quality. For the true stereo enthusiast, we offer the Recoton self-amplified wireless satellite subwoofer system. The satellite speakers in the system each bolster 25 watts of clean, distortion-free sound. The subwoofer adds a whole new dimension to your home theater with its 50-watt amplifier that's capable of creating enough rumble to make you feel like you're in the middle of an earthquake.

The Recoton wireless subwoofer's 50-watt 10-inch speaker delivers thunderous bass that adds depth and realism to the surround sound experience.

Even the most discriminating surround sound enthusiast will be engulfed by the abundant power and delighted with the full-range, first-rate sound from these black oak vinyl veneer speakers.

Easy to install. Every speaker option offered by Comtrad can be easily installed with the HTS-1 in a matter of minutes. Just connect the speaker outputs of your receiver or amp to the HTS-1, then connect speaker wire to the front and rear speakers. When using wireless speakers, connect the transmitter to the output. One transmitter will broadcast to each wireless speaker.

Risk-free home trial. The best way to evaluate surround sound is in your home—not a showroom. That's why we're offering the 30-day risk-free home trial. Try these products in your home and if you're not delighted with the the surround sound experience, return them for a full "No Questions Asked" refund.

HTS-1 surround sound decoder........$99 $10 S&H

Please mention promotional code 711-ET-1107.

For fastest service call toll-free 24 hours a day

800-704-1211

To order by mail, send check or money order for the total amount including S&H (VA residents add 4.5% sales tax.) Or charge it to your credit card, enclosing your account number and expiration date.

COMTRAD INDUSTRIES
2820 Waterford Lake Drive, Suite 106
Midlothian, Virginia 23113

inhibitors. It is effective in the temperature range of −34°C to 200°C.

DeoxIT is sold in spray and liquid containers and in wipes and pen applicators. Prices start at $3.95 for a 2.3-milliliter vial.

Caig Laboratories, Inc.
16744 West Bernardo Drive, San Diego, CA 92127-1904
Phone: 619-451-179
Fax: 619-451-2799

"GREEN" MICROCONTROLLER. The MTE1122 energy management controller from Microchip Technology reduces total energy consumption up to 30% in products powered by AC motors. It is suitable for installation in residential, commercial, and industrial equipment and appliances such as refrigerators, washing machines, dryers, and heating, ventilation, and air-conditioning (HVAC) equipment.

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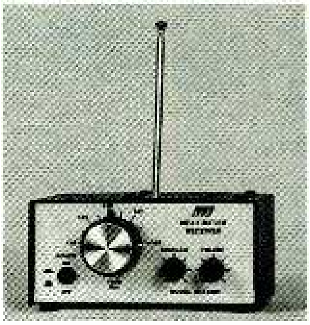
The MTE1122 controller includes Microchip's eight-bit, RISC-based PIC16/17 microcontroller with proprietary power-management firmware. The controller monitors the motor load and then digitally controls power consumption by sampling at high rates.

When an AC motor is operating under light or no-load conditions, the controller monitors the AC signal and senses when the motor is consuming more power than is required. It then modifies the AC signal to allow the motor to rotate at the same speed and maintain that speed while consuming less power.

MTE1122 energy management controllers are packaged in 18-pin plastic DIP and SOIC packages and work from 5-volt sources. The list price for the plastic DIP version is $7.49 each in thousand-piece quantities.

Microchip Technology Inc.
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Phone: 602-786-7200
Fax: 602-899-9210

TWO-METER REPEATER MONITOR/RECEIVER KIT. The MFJ-8400K repeater monitor receiver kit from MFJ Associates is intended for the circuit builder who wants to build a two-meter receiver that will rival factory-made units costing hundreds of dollars more.



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The completed monitor receiver offers a low-noise, high-gain, radio-frequency preamplifier for hearing weak signals. An air-variable tuning capacitor with a smooth 6:1 reduction drive simplifies receiver tuning. A dual-conversion superheterodyne receiver with ceramic filters and a crystal-controlled second oscillator is said to provide excellent selectivity and stability.

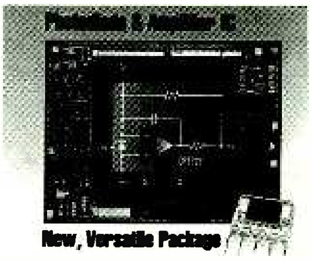
A 19-inch, ¼-wave whip antenna is included in the kit. A 50-ohm antenna input accepts an external groundplane or Yagi antenna array.

The MFJ-8400K kit with a circuit board, metal cabinet, and an instruction manual is priced at $69.95. A wired and tested receiver (MFJ-8400W) is priced at $89.95.

MFJ Enterprises, Inc.
P. O. Box 494
Mississippi State, MS 39762
Phone: 601-323-5869
Fax: 601-323-6551

PHOTODIODE/AMPLIFIER IC. The OPT202 photodiode/amplifier from Burr-Brown is packaged in a five-pin, single-in-line package. It includes a 0.09-inch square photodiode, a precision FET-input transimpedance amplifier, and a 1-megohm feedback resistor on a single substrate. Its package allows light to enter the side of the package rather than from perpendicular sources.

The OPT202 is intended for industrial, medical, and laboratory instrumentation, position and proximity sensors, photographic analyzers, machine tool controllers, and smoke detectors. The integrated device offers advantages over hybrid or discrete equivalent circuits by reducing or eliminating leakage-current errors, noise pick-up, and gain peaking from stray capacitance. The photodiode responsivity is 0.45 amperes per watt at 650 nanometers.



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OPT202 photodiode/amplifier ICs are priced at $4.95 each in quantities of thousands.

Burr-Brown Corporation
Mary Douglas, Inquiry Handling Manager
P. O. Box 11400
Tucson, AZ 85734
Tel: 602-746-1111
Fax: 602-889-1510 Ω

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Wake up! You may be the victim of stolen words—precious ideas that would have made you very wealthy! Yes, professionals, even rank amateurs, may be listening to your most private conversations.

Wake up! If you are not the victim, then you are surrounded by countless victims who need your help if you know how to discover telephone taps, locate bugs, or "sweep" a room clean.

There is a thriving professional service steeped in high-tech techniques that you can become a part of! But first, you must know and understand Countersurveilance Technology. Your very first insight into this highly rewarding field is made possible by a video VHS presentation that you cannot view on broadcast television, satellite, or cable. It presents an informative program prepared by professionals in the field who know their industry, its techniques, kinks and loopholes. Men who can tell you more in 45 minutes in a straightforward, exclusive talk than was ever attempted before.

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Discover the targets professional snoopers seek out! The prey are stock brokers, arbitrage firms, manufacturers, high-tech companies, any competitive industry, or even small businnesses in the same community. The valuable information they filch may be marketing strategies, customer lists, product formulas, manufacturing techniques, even advertising plans. Information thieves eavesdrop on court decisions, bidding information, financial data. The list is unlimited in the mind of man—especially if he is a thief!

You know that the Russians secretly installed countless microphones in the concrete work of the American Embassy building in Moscow. They converted what was to be an embassy and private residence into the most sophisticated recording studio the world had ever known. The building had to be torn down in order to remove all the bugs.

Stolen Information

The open taps from where the information pours out may be from FAX's, computer communications, telephone calls, and everyday business meetings and lunchtime encounters. Businessmen need counselling on how to eliminate this information drain. Basic telephone use coupled with the user's understanding that someone may be listening or recording vital data and information greatly reduces the opportunity for others to purloin meaningful information.

CLAGGK INC. **EN**
P.O. Box 4099 • Farmingdale, NY 11735

Please rush my copy of the Countersurveillance Techniques Video VHS Cassette for a total cost of $53.95 each (which includes $4.00 postage and handling).

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The professional discussions seen on the TV screen in your home reveals how to detect and disable wiretaps, midget radio-frequency transmitters, and other bugs, plus when to use disinformation to confuse the unwanted listener, and the technique of voice scrambling telephone communications. In fact, do you know how to look for a bug, where to look for a bug, and what to do when you find it?

Bugs of a very small size are easy to build and they can be placed quickly in a matter of seconds, in any object or room. Today you may have used a telephone handset that was bugged. It probably contained three bugs. One was a phony bug to fool you into believing you found a bug and secured the telephone. The second bug placates the investigator when he finds the real thing! And the third bug is found only by the professional, who continued to search just in case there were more bugs.

The professional is not without his tools. Special equipment has been designed so that the professional can sweep a room so that he can detect voice-activated (VOX) and remote-activated bugs. Some of this equipment can be operated by novices, others require a trained countersurveillance professional.

The professionals viewed on your television screen reveal information on the latest technological advances like laser-beam snoopers that are installed hundreds of feet away from the room they snoop on. The professionals disclose that computers yield information too easily.

This advertisement was not written by a countersurveillance professional, but by a beginner whose only experience came from viewing the video tape in the privacy of his home. After you review the video carefully and understand its contents, you have taken the first important step in either acquiring professional help with your surveillance problems, or you may very well consider a career as a countersurveillance professional.

The Dollars You Save

To obtain the information contained in the video VHS cassette, you would attend a professional seminar costing $350-750 and possibly pay hundreds of dollars more if you had to travel to a distant city to attend. Now, for only $49.95 (plus $4.00 P&H) you can view ***Countersurveillance Techniques*** at home and take refresher views often. To obtain your copy, complete the coupon or call.

NEW LITERATURE

Use The Free Information Card for fast response.

Create Your Own Multimedia System; by John McCormick. Windcrest/McGraw-Hill, Blue Ridge Summit, PA 17294-0850; Phone: 1-800-233-1128; Fax: 717-794-2103; $32.95, including disk.

This book explains how to assemble a complete multimedia production system including monitors, input devices, CD-ROM drives, MIDI sound controllers and software. It explains multimedia issues, including computer system requirements, performance specifications, hardware and software sources, installation procedures, and operation tips. The diskette included with McCormick's book contains sample commercial multimedia demonstration and shareware programs.

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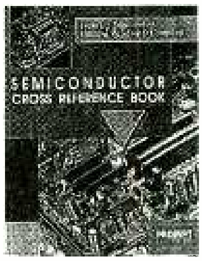
The topics covered in this book include Macintosh and IBM PC and compatible operating environments; graphics, sound, and animation hardware and software; JPEG, MPEG, QuickTime and other compression standards; and storage devices and CD-ROM drives.

Semiconductor Cross Reference Book; from the Engineers of Howard W. Sams & Company. Prompt Publications, 2647 Waterfront Parkway, East Drive, Indianapolis, IN 46214-2012; Phone: 800-428-7267 or 317-298-5710; Fax: 317-298-5604; $24.95.



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This book from the publishers of "Photofact" documentation is a cross-reference guide for semiconductor device replacements and substitutions. It includes more than 490,000 part numbers, type numbers, and other identification for devices made in the United States, Europe, and the Far East.

By including replacements for NTE, ECG, Radio Shack, and TCE devices, the book functions as a four-way cross reference. All major classes of semiconductors are included: bipolar transistors, MOSFETs, diodes, rectifiers, ICs, and SCRs. Light-emitting diodes and thermal sensors are also included. An appendix has an updated listing of device original equipment manufacturers.

1995 Full-Line Catalog. Hub Material Company (HMC), 33 Springdale Avenue, Canton, MA 02021; Phone: 617-821-1870; Fax: 821-4133; free.

This pictorial 1995 catalog from Hub Material Co. includes descriptions of tools, test equipment, and technical materials for the assembly, testing, and repair of electronic products offered by Hub.

Among the items listed and pictured in this catalog are precision hand tools including screwdrivers, pliers, wire strippers, and tweezers. Soldering supplies include solder, fluxes,

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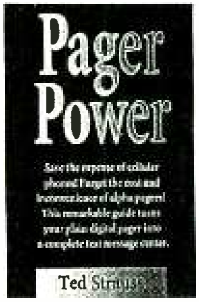
soldering irons, tips, sponges and wicks. ESD prevention products include wrist straps, protective bags, conductive mats, and special tools. Test equipment includes power supplies and oscilloscopes. Also offered are tool kits and cases. The catalog contains tables for comparing the product features.

Pager Power; by Ted Strauss. Ten Speed Press, P. O. Box 7123; Berkeley, CA 94707; Phone: 800-841-2665 or 510-559-1600; Fax: 510-524-4588; $4.95.

This pocket-sized book explains how to turn your inexpensive numeric pager into a powerful communications device and save the expense of a cellular phone. The techniques described also save money



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over the use of alphanumeric pagers.

A handy code dictionary in the book provides more than 11,000 easy-to-use codes for frequently used words and phrases. It also gives users an easy way to add many personally selected words and phrases. A form at the back of the book, when filled in, becomes a directory for active names and phone numbers. You look up the words and phrases to be sent, key in the recipient's pager number, and press the code numbers. The recipient looks up the code or codes in his copy of your code book to interpret the message.

Entries include single words that are listed alphabetically and phrases that are listed both by situation (e.g., change in plans, emergency, reminders) and alphabetic order. The book provides XPress codes (those most often used) and shortcuts (100 of the most frequently used words, prefixes, and suffixes).

Data Acquisition Catalog & Reference Guide. Keithley MetraByte, 440 Myles Standish Blvd., Taunton, MA 02780; Phone:

1-800-348-0033; Fax: 508-880-0179; free.

This 288-page catalog from Keithley MetraByte describes more than 40 hardware, software, and accessory products that it is offering. Many have been optimized for Windows-based data-acquisition applications. The products pictured and described include the DAS-1800 and DAS-800 families of plug-in data-acquisition boards, the DAS-TC thermocouple input board, the VisualDAS custom control software package, and the TestPoint multitasking, object-oriented software package.

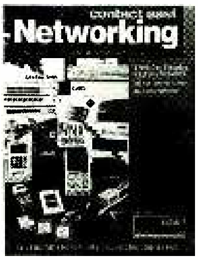
The full color catalog also describes the company's plug-in boards and software packages, signal-conditioning products and accessories, IEEE-488.2 personal computerinterfaces, serial interfaces, Personal Computer Instrument Product (PCIP) boards, Series 500 data acquisition instruments, and industrial data acquisition systems.

CIRCLE 341 ON FREE INFORMATION CARD

Expanded technical reference sections include product-selection indexes, application notes, technical tips, and a glossary. An enclosed project block-diagram worksheet is intended to help readers document their application requirements. Worksheets can be faxed to Keithely MetraByte for free advice on the most cost-effective way to implement those requirements.

Networking: Products for Installing, Maintaining & Repairing Networks. Contact East, 335 Willow Street, North Andover, MA 01845; Phone: 508-688-2000; Fax: 508-688-7829; free.

This 48-page catalog from Contact East contains information on its products for installing, maintaining, and repairing networks. The products highlighted in this catalog include new insulated hand tools, digital multimeters and accessories, cordless power tools, clamp meters, infrared temperature probes, and handheld and remote digital storage oscilloscopes.



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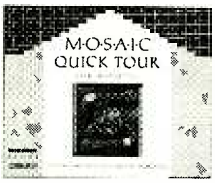
The catalog also describes Contact East's lines of tools for wire crimping, stripping, and cutting as well as its soldering supplies, wire sorters, circuit testers, network testers, communication test equipment, and measuring tools.

Mosaic Quick Tour for Windows: Accessing & Navigating the Internet's World Wide Web; by Gareth Branwyn. Ventana Press, P. O. Box 2468, Chapel Hill, NC 27515; Phone: 919-942-0220; Fax: 919-942-1140; $12.

This book describes the World Wide Web, a system for interlinking information on the Internet. Mosaic, with its graphically rich interface and point-and-click access, is said to be ideal for navigating the Web. Branwyn's book will help



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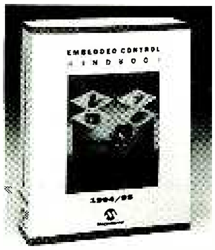
the reader to obtain maximum benefit from Mosaic.

The book defines hyperlinked World Wide Web, Mosaic, hypertext, and HTML, and it discusses its underlying language. Also covered are system requirements and software downloading and configuration. You will learn how to use Mosaic for FTP, telnet, and newsgroup reading. The book also contains a listing of art galleries, magazines, music archives, software libraries, and other resources. It also describes special ways to explore the World Wide Web.

1994/1995 Embedded Control Handbook. Microchip Technology Inc., 2355 West Chandler Blvd., Chandler, AZ 85224-6199; Phone: 602-786-7200; Fax: 602-899-9210; free

This 1376-page technical reference book from Microchip Technology on embedded control is available through any authorized Microchip distributor or sales representative. It discusses Microchip's PIC16/17 field-programmable eight-bit microcontrollers and nonvolatile memory products. In-



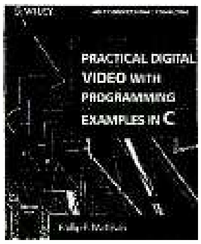
CIRCLE 344 ON FREE INFORMATION CARD

cluded are more than 78 application notes as well as software code written for specific embedded-control applications.

Sections include those on multiplexing LED drives and a 4 × 4 keypad for sampling; implementation of an asynchronous serial I/O; serial port utilities; implementing ohmmeter/temperature sensors and serial port utilities. The book includes schematic and timing diagrams, math routines, and illustrations to explain applications.

Practical Digital Video with Programming Examples in C; by Phillip Mattison. John Wiley & Sons, Inc. 605 Third Avenue, New York, NY 10158-0012; Phone: 1-800-CALL-WILEY; $39.95 including disk.

Mattison's book will help software developers gain a comprehensive working knowledge of digital video and multimedia programming in C language. This practical guide explains the vital elements of personal computer motion video in a comprehensible, non-mathematical style. The companion diskette includes 20 sample programs with source code, plus clips of sample motion videos.



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The book points out the differences between graphical and natural images, and the reasons for compressing image data. It describes and compares various computer displays and comments on their suitability for natural video. Different methods of color representation are explained, and their applications to multimedia are described. Also covered are available video-storage techniques and major data-compression techniques. It presents several PC video hardware systems, and discusses two popular PC video environments—Microsoft Video for Windows and Apple Quicktime.

CIRCLE 346 ON FREE INFORMATION CARD

Mega-Brite Lites Selection Guide No. 84-3. Lumex Opto/Components Inc., 292 East Hellen Road, Palatine, IL 60067; Phone: 708-359-2790; Fax: 1-800-944-2790; free.

This product selection guide describes a family of 35 high-intensity red, green, and yellow light-emitting diodes sold under the Mega-brite Lites label. Available in six sizes of radial-leaded plastic packages, the LEDs can serve as illumination sources, indicators that can be seen as far away as 100 feet, and indoor signs. They can also serve as outdoor lights automobiles. The guide includes full specifications, including detailed outline drawings and emission patterns for each of the six package sizes. Ω

EQUIPMENT REPORTS

continued from page 16

burst, and text. The patterns can be cycled automatically to prevent the electron beam from damaging the CRT screen of the monitor under test.

The *raster* pattern produces a solid box on the monitor's screen surrounded by a one-pixel wide border. This border indicates color purity and high-voltage power supply regulation. The box should be pure white when all video outputs are on, and it should switch to solid black when the video polarity is reversed. The edges of the box must be straight and ripple-free.

The *circle/cross* pattern of light colored circles and grid on a black background provides a test of the monitor's linearity and convergence. Each line should be straight and each box should be square. The circles must be round and without distortion. The dots permit checking static convergence and the dots and lines permit checking dynamic convergence.

The *color bar* pattern tests a monitor's ability to produce proper color. All color bars should be present and the colors should be uniform in intensity from top to bottom and left to right to detect possible video amplifier defects.

The *staircase* pattern tests brightness and contrast linearity of analog and monochrome digital monitors. If those monitors are working correctly, they will display of 16 evenly spaced bars ranging from black to 100 % white.

The *windows* pattern tests the monitor's power supply regulation. It shows up as a checkerboard pattern of four black and five white squares on a field of nine squares. Transitions between the black and white squares should be clear and distinct. All the white boxes should have the same brightness level and the entire screen should be ripple free.

The *window* pattern, a white box on a black field, is widely used by monitor manufacturers for making internal contrast and brightness adjustments.

The *multiburst* pattern, similar in appearance to the *windows* pattern except that the vertical and horizontal resolution lines replace the white boxes, test monitor resolution and bandwidth. The vertical lines test the horizontal pixel resolution and the horizontal lines test the vertical resolution. The one-pixel wide lines should be discernible on a properly operating monitor.

The *text* pattern fills the screen with upper- and lower-case text characters that duplicate user conditions. All characters on the screen should be should be focused and easy to read. This pattern is used to make the final performance test on the monitor.

The CM125 computer monitor signal generator is an expensive instrument, but its performance is not easily matched by features in other computer monitor testers at any price, especially portable instruments suitable for field use. It can make short work of high-volume symptom, field, burn-in testing, and quality assurance testing. It is also suitable for giving monitor demonstrations. Ω

MICROPROCESSORS

Two decades of microprocessor history

STEPHEN J. BIGELOW

SINCE THE DAYS OF THE FIRST VACuum-tube computer, designers have sought better, faster, and cheaper computer performance. Improvements in these areas directly mirror the evolution of device technology from vacuum tubes to transistors, integrated circuits, Large Scale Integration (LSI), and Very Large Scale Integration (VLSI). Important milestones along the way include the introduction of integrated circuits in 1964, and the introduction of the microprocessor—often called the MPU (microprocessing unit) or, more commonly, CPU (central processing unit)—in 1971.

This article provides an overview of how both microprocessors and the computer industry have evolved. Whether you are a computer user, hobbyist, technician, or designer, this article will help you understand what microprocessors are, how they work, and how they developed. The article also includes a capsule history of microprocessor development (see "Early Times in the PC Biz"), and a glossary of microprocessor-related terms (see "Microprocessor Glossary and Nomenclature").

What is a microprocessor?

The internal workings of today's microprocessors are certainly more sophisticated than those of such pioneers as the 6502 (MOS Technology), the MC6800 (Motorola) or the 8080 (Intel). Even so, today's complexity only builds on underlying architectures that have remained almost unchanged for 20 years.

At heart, the microprocessor is an "engine" that performs arithmetic and logic functions in a generalized way. Ordinary logic ICs are designed to produce specific outputs based on specific inputs and internal logic. By contrast, the microprocessor's outputs are determined by stored logic—software—that can vary.

For example, Fig. 1 shows a block diagram of the 8-bit 8080A CPU. Although it might appear imposing at first glance, each block falls into one of three categories: registers, instruction/control elements, and the arithmetic logic unit or ALU.

Registers are individual RAM locations that are contained within the microprocessor itself. Nearly every microprocessor has a register called the *accumulator*, which stores values and the results of arithmetic and logical operations.

Another important register shared by nearly all microprocessors is called the *program counter*, which tracks the address in the computer's main RAM memory where the next program instruction will come from. While the microprocessor is executing a current instruction, it also updates the program counter to point to the address of the next instruction. The actual program instruction that is to be executed is passed to the *instruction decoder* via the *instruction register*.

The CPU can also jump to another location in RAM to execute an instruction, in several ways. One is to Jump or Branch directly to that location and continue program execution there. Another is to execute a *subroutine*, usually via a Call, Jump to Subroutine, or Branch to Subroutine instruction. After the subroutine completes its duties, the CPU resumes program execution at the instruction that immediately follows subroutine-Call, -Jump, or -Branch instruction.

When the CPU performs a Call, it *pushes* the contents of the program counter onto a special section of main computer memory called the *stack*. Conversely, when returning from a subroutine, the address is then *popped* off the stack and loaded back into the program counter. Another CPU register called the *stack pointer* keeps track of the next free location on the stack. As the CPU calls subroutines (pushes) and returns from them (pops), the stack pointer slides up and down the stack. The stack can also store the contents of various CPU registers.

Other registers are used for temporary data storage and to index memory. For example, in the 8080, the H, L, D, E, B, C, W, Z, as well as the Accumulator, are all 8-bit registers that serve as general-purpose (or *scratchpad*) registers. Newer microprocessors contain more and larger registers, but the concept is the same.

Instruction/Control To execute a program instruction, the CPU must usually perform a series of steps such as reading data from a memory or input/output (I/O) location, writing data to a memory or I/O location, manipulating the contents of one or more CPU registers, and handling the results of ALU operations. The actual series of steps depends on the particular instruction. Thus, each instruction must be translated by an *instruction decoder* from the single machine-language instruction into a series of simple functions that the CPU can execute.

Keeping all of the components of a CPU running smoothly re-

MOTOROLA's 68030 second-generation 32-bit microprocessor.

quires precise timing and synchronization, which is usually managed by a crystal-based clock/oscillator. Early CPUs such as the 8080A required an external oscillator. Today's CPUs contain internal oscillators that require only an external crystal and perhaps a small capacitor or two.

Each clock pulse allows the CPU to perform one operation. However, one instruction can requires several operations. As a result, it may take 20 to 30 clock pulses for a CPU to perform a complete instruction, such as adding two numbers.

There are two basic ways to enhance CPU speed: 1) increase clock speed, and 2) decrease the number of operations that are required to execute each instruction. For example, suppose that 25 clock pulses are needed to perform a simple addition. If the CPU clock ran at 10 MHz, each clock pulse would take 0.1 microsecond (μs), so the addition would be completed in (25×0.1 μs) = 2.5 μs. If the CPU ran at 60 MHz, each clock pulse would be only 16.7 nanoseconds (0.0167 μs), so the same addition would be complete in (25×0.0167 μs) = 0.4175 μs. That value represents a six times improvement in raw speed. The other way to improve performance is to reduce the number of operations required per instruction. Today's microprocessors use both techniques.

Several control signals influence a microprocessor's operation. One important function, for example, is reading and writing memory and I/O ports. How does the system distinguish between reads and writes? Some microprocessor families have a single read/write line; the Intel family has separate read and write lines. Whenever the CPU wants to write some data to memory or to an input/output (I/O) port, it asserts (brings low) its WRITE line. Likewise, when it wants to read data, it asserts its READ line.

Another important function involves *interrupts*. Whenever a situation requiring the CPU's attention occurs, the CPU's current task can be interrupted, and its focus shifted to the interrupting task. Devices such as keyboards, disk drives, and memory-refresh circuits demand the CPU's attention with *interrupt requests* (IRQs). Early CPUs such as the 6800, the 6502, and the 8080 had a single interrupt input. Many current devices offer as many as 16.

Another potential problem that a microprocessor must contend with is the varying speeds of devices in a computer system. The CPU is usually the fastest device in a system; memory and I/O ports are typically slower, and mechanical devices such as disk drives are slower yet. Because of these speed differences, an external device may not be ready when the CPU tries to read it. To ensure coordination, microprocessors have WAIT and READY signal lines, which allow the CPU to idle for a clock pulse. That idle period is called a *wait state*. Although wait states are still common in computer systems today, good system design minimizes their use.

The last control function to be discussed here is microprocessor reset. When asserted, the RESET line of a microprocessor sets all the registers to known states and begins program execution at a specific location in memory.

ALU The real power in a CPU is not in its registers or control section, but in its *Arithmetic/Logic Unit* (ALU). The ALU is the "brain" within the CPU; it is what carries out most logical operations, comparisons, and arithmetic functions. Some CPUs delegate high-order math functions to a separate math coprocessor, but most ALUs add, subtract, increment, decrement, compare, and perform logical operations (AND, OR, NOT, XOR). After each ALU operation, a set of *result flags* indicates the status of the result (carry, borrow, or zero).

The Intel family

Intel CPUs have been at the forefront of desktop personal computing since IBM selected the 8088 for use in its first IBM PC. Since it was introduced, the so-called x86 architecture has undergone five major evolutionary stages. The first generation includes the 8088, the 8086, and the 80186. The next three generations include the 80286, the 80386, and the 80486. The fifth and most recent includes the Pentium. Intel is already working on both the sixth and seventh generations, as yet unnamed. Table 1 summarizes differences between the various CPU family members, ranging from the early 8088 (as used in the original IBM PC) to what many consider today's performance leader, the Pentium.

The head of the family is the 8086. In the era ruled by 8-bit microprocessors, the 8086 quickly became the first widely-used 16-bit microprocessor. (When speaking of the number of bits a microprocessor has, data-bus width is usually the value referred to.) In addition to doubling the data bus width from 8 to 16, the 8086 also increased the number of address lines from 16 to 20, thereby providing what seemed at the time an abundant one megabyte of addressable memory.

The 8088 is essentially the same chip as the 8086, except that its 16-bit data bus is multiplexed down to 8 bits. That trades off system costs at the expense of performance. Note in Table 1 how data-bus bandwidth decreases by more than a factor of two from the 8086 to the 8088. Multiplexing the data bus down to half its internal width is a "trick" Intel played over and over in the evolution of the 8086 line.

The 80186 is an 8086 with several common support functions built right in: clock generator, system controller, interrupt controller, DMA (Direct Memory Access) controller, and timer/counter. No Intel CPU before or since has offered as much integration in a single package. The 80186 was also the first to abandon 5-MHz clock speeds in favor of 8-, 10-, and 12.5-MHz rates. The 186 was not used as a mainstream CPU for desktop computers; rather, it was limited to "embedded" applications.

The 80286 offered the first real architectural advance over the 8086. The 286 pushed memory to 24 address lines, resulting in a 16-megabyte address space. In order the access all that memory, the 286 also introduced a new mode of operation, called *protected mode*.

The 80286 booted in an 8088/86-compatible mode called *real mode*, but through a special instruction, it could switch into the more advanced protected mode to gain access to the additional memory, as well as to advanced programming features. However the only way to get back into real mode from protected mode is to force a complete reset of the microprocessor—a time-consuming process that eliminated the 80286 as a viable engine for running multitasking operating systems such as Windows and OS/2.

The next major advance came in 1985: the 80386. It was Intel's first 32-bit microprocessor, and

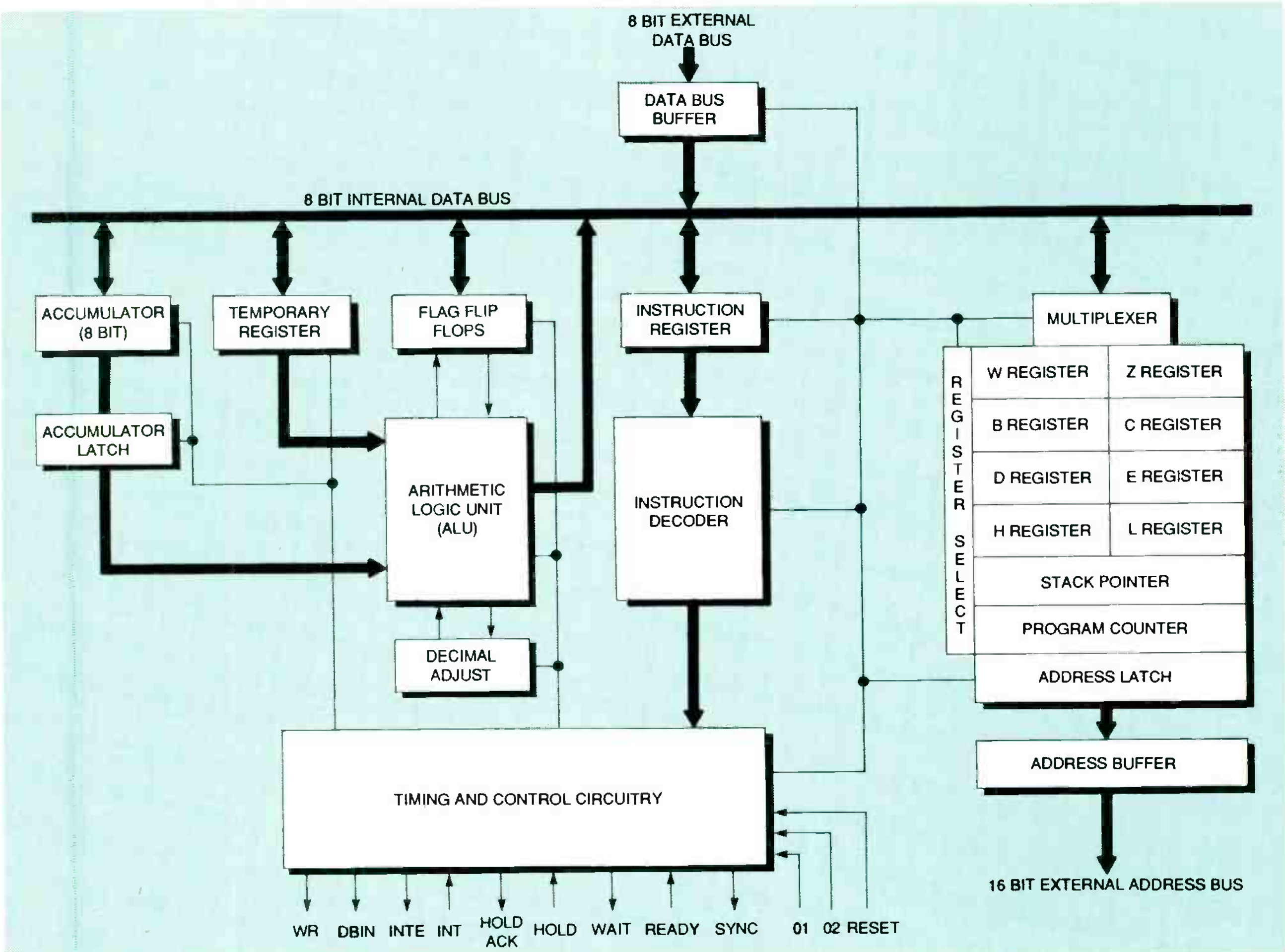

FIG. 1—ARCHITECTURE FOR A GENERATION: Intel's 8088 microprocessor, as used in the original IBM PC.

TABLE 1—INTEL CPU FAMILY CHARACTERISTICS

CPU	Date Introduced	Number of Transistors	Data Bits	Address Bits	Physical Address Space (Virtual)	Clock Speeds (MHz)	Data Bus Bandwidth (MB/sec)	MIPS (at Max Clock Speed)	Math Coprocessor
8086	1978	29.00	16	20	1 MB	5, 8, 10	5	0.75	8087
8088	1978		16 (8 external)	20	1 MB	5, 8	2	0.75	8087
80186	1980		16	20	1 MB	8, 10, 12.5			
80286	1982	134.000		24	16 MB (1 GB)	8. 10, 12.5	12.5	2.66	80287
80386	1985	275.000	32	32	4 GB (64 TB)	16, 20, 25, 33	50	11.4	80387
80386SX	1988		32 (16 external)	24	16 MB	16. 20, 33		3.6	80387SX
80386SL	1990	855.000 external)	32 (16	24	16 MB	16, 20, 33			80387SL
80486	1989	1.200.00	32	32	4 GB (64 TB)	25, 33		26.9	Internal
80486SX	1991		32	32	4 GB (64 TB)	16. 20, 25, 33		20.2	80487
80486 DX/50	1991		32	32	4 GB (64 TB)	50		41.1	Internal
80486DX2/50	1992		32	32	4 GB (64 TB)	25 (50 internal)		40.5	Internal
80486DX2/66	1992				4 GB (64 TB)	33 (66 internal)		54.4	Internal
80486SL	1992	1.400.000	32	32	4 GB (64 TB)	25, 33		26.9	Internal
80486dx2/40	1993				4 GB (64 TB)	20 (40 Internal)		21.1	Internal
80486SX/SL	1993				4 GB (64 TB)	33		26.9	Internal
80486DX/SL	1993				4 GB (64 TB)	33		26.9	Internal
80486DX4	1994				4 GB (64 TB)	33 (100 internal)			Internal
Pentium	1993	3,210.000	64 (32 internal)	32	16 MB (64 TB)	60, 66, 90, 100		111.6 (at 66 MHz)	Internal

provided 32 bits on both the data and address buses. Like the 286, the 386 boots in real mode. It also offers a protected mode, multiple simultaneous "virtual" real-mode sessions, and efficient mode switching. The 386 was the first Intel CPU to enhance processing speed through the use of *instruction pipelining* (also known as *scalar* architecture), which allows the CPU to start working on a new instruction before completing the current one.

In 1988, Intel took a step "backward" with the 80386SX. It was built around the core 32-bit CPU of the 386, but provided only a 16-bit external data bus, and a 24-bit address bus. Although the performance of the 386SX was significantly lower than the 386, so was it's price, so system costs could be reduced. Another version of the 386 came in 1990: the 80386SL. With its 24 address lines and 16-bit external data bus, the 386SL closely resembled the 386SX. But it also incorporated system functions for running a standard PC, and power-management circuitry that optimized the device for use in portable computers.

All members of the 386 family can operate with stand-alone math coprocessors (80387DX, 80387SX, and 80387SL).

The 486 family

Like the 80386, the 80486 incorporates pipelining to improve instruction execution performance. The 486 also adds a new wrinkle: on-chip cache memory. Cache reduces memory-access time by storing copies of recently used instructions and data in fast static RAM, rather than relatively slow DRAM. Another improvement was the inclusion of a floating-point unit in the CPU itself.

Of course, Intel found ways to "SX" the 486 line to provide a less expensive option for system designers. Unlike previous SXs, the data-bus width was not halved on the 486SX. However, the 486SX does not include the on-chip floating-point unit or math coprocessor. One important innovation in the 486 line was the introduction of 3-volt devices for laptop computers and other low-power applications.

Another interesting feature of the 486 is its upgradeability. Computer systems based on prior generations were pretty much locked in to the performance level attainable by whatever the built-in CPU offered. But the 486 was designed from the beginning for upgradeability via what Intel calls "OverDrive" technology. OverDrive technology generally replaces your current CPU with one that runs twice as fast—internally. But you don't get twiçe the overall performance. Nonetheless, an OverDrive CPU is cheaper than buying a whole new PC. It is vital to note that not all 486 systems are upgradeable via OverDrive technology; check with your computer's manufacturer to be sure.

The 486 has spawned numerous variations, including a full 50-MHz model (the 80486DX/50), and the aforementioned 486SX, which is upgradeable if the computer's motherboard was designed to accept an OverDrive CPU.

The first wave of OverDrive CPUs arrived in 1992 with the introduction of the 80486DX2/50 and the 80486DX2/66. The DX2/50

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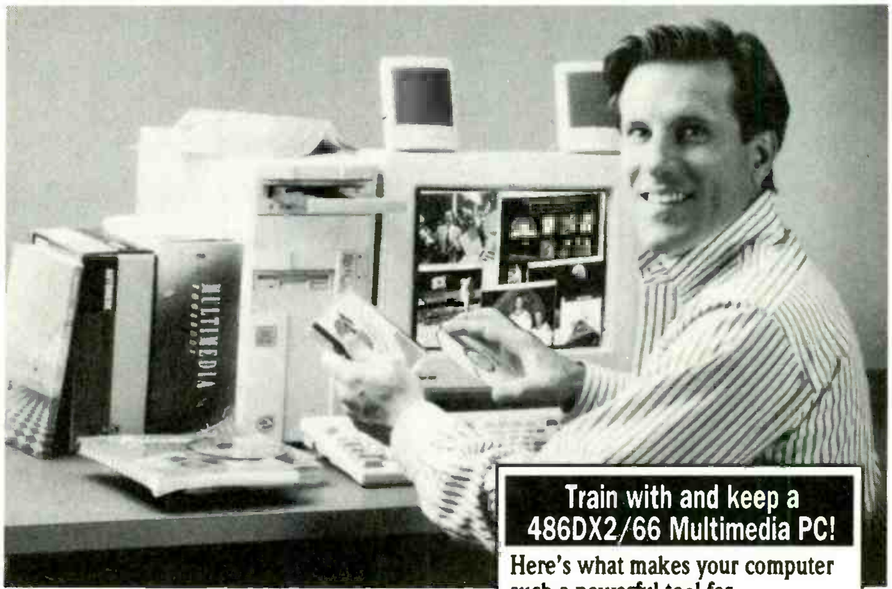

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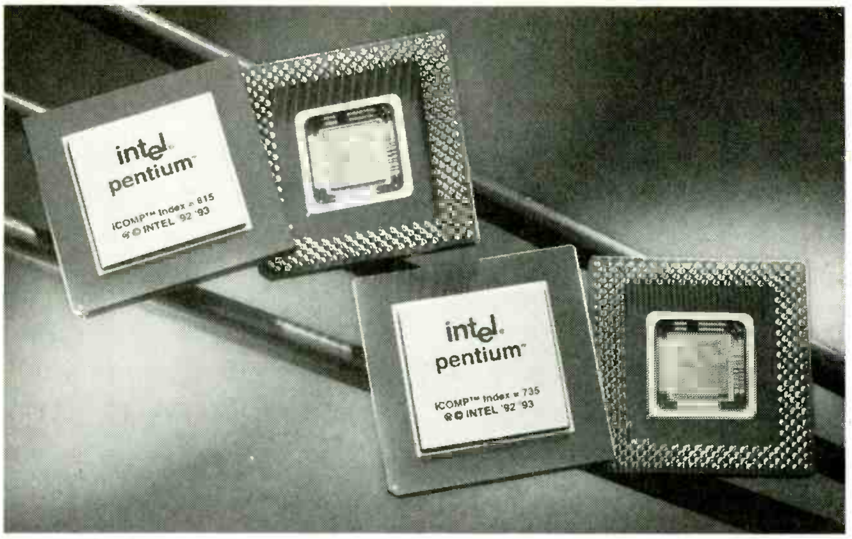


INTEL's Pentium.

runs on a 25-MHz bus, but at 50-MHz internally; the DX2/66 runs at 66 MHz on a 33-MHz bus. The slower bus speeds allowed the OverDrive CPUs to work directly with existing PC motherboard designs. Both OverDrive CPUs offer internal math coprocessors, and are themselves upgradeable to even faster OverDrive versions. The DX2/50 is available in 3- and 5-volt versions, while the DX2/66 is available only in the 5-volt version.

In 1992, Intel produced a highly-integrated, low-power version of the 80486 called the 80486SL. Its 32-bit data bus, 32-bit address bus, 8 kilobytes of on-board cache, and integrated math coprocessor make it similar to other 486 CPUs. However, the SL includes power-management circuitry that optimizes the device for use in mobile computers. The 486SL is available in 25- and 33-MHz versions, and in both 3- and 5-volt designs.

In 1993 Intel rounded out the 486 family by introducing the 486DX2/40, the 80486SX/SL, and the 80486DX/SL. The DX2/40 is another OverDrive CPU, this one intended to run in 20-MHz PCs. The SX/SL and DX/SL devices are similar to the original versions, but with SL-type power-management capabilities. These devices in essence made the special 486SL mentioned previously obsolete, angering several manufacturers in the process.

The latest addition to the 486 line is the DX4 series, which are clock-*tripled* devices that run on 25- and 33-MHz buses. With the X4 nomenclature Intel appears to imply that the DX4's larger cache (16 kilobytes vs. 8 kilobytes in prior models) achieves greater than a three times performance improvement. All versions of the 486 run the same software, and are backward compatible with all x86 CPUs going all the way back to the 8086/8088.

The Pentium

By 1992, the 486 had become well-entrenched in everyday desktop computing, but Intel was already laying the groundwork for the next generation. Nearly everyone expected Intel to continue its traditional numbering scheme and dub the next CPU the 80586. However, Intel wanted more control over who used similar names for competing processors, so it changed to a name that is more easily trademarked: Pentium. It was introduced in 1993.

The Pentium retains the 32-bit address bus of the 486, but doubles the data bus to 64 bits. All versions of the Pentium include an on-board math coprocessor, and are intended

Early Times in the PC Biz

The CPU powering the PC on your desk probably contains more than a million transistors. However, its lineage traces all the back to Intel's 4004, which was developed in 1971. The 4004 was a four-bit processor. It contained 2,300 transistors, and ran at 108 kHz. The 4004 sold well and found service in early desktop calculators.

Following the 4004, Intel developed the 8008 (in 1972) and the 8080 (in 1974). It was the 8080 that really helped launch the personal-computer revolution. The 8080 could address only 64 kilobytes of memory, but it was the first well-accepted 8-bit microprocessor. Later (in 1976) Intel introduced the 8085, which was basically an 8080 with some built-in system logic. Then a company called Zilog produced what was probably the first clone microprocessor, the Z80. The Z80 was 8080 compatible, but included enhancements such as faster clock rates and a richer instruction set. Motorola entered the CPU market in 1975 with its 8-bit 6800, and the 6502 was developed around the same time by MOS Technology.

By the late 1970's, the first wave of personal computers had hit the market. Tandy introduced the 8080-based TRS-80 Model I in 1977. The 6502-based Apple II also appeared in 1977. In 1979 came the 6502-based Commodore PET. Dozens of companies produced 8080- and Z80-based machines that ran the first "business" operating system, CP/M. CP/M originally stood for Control Program/Monitor, but eventually took on the meaning Control Program for Microcomputers.

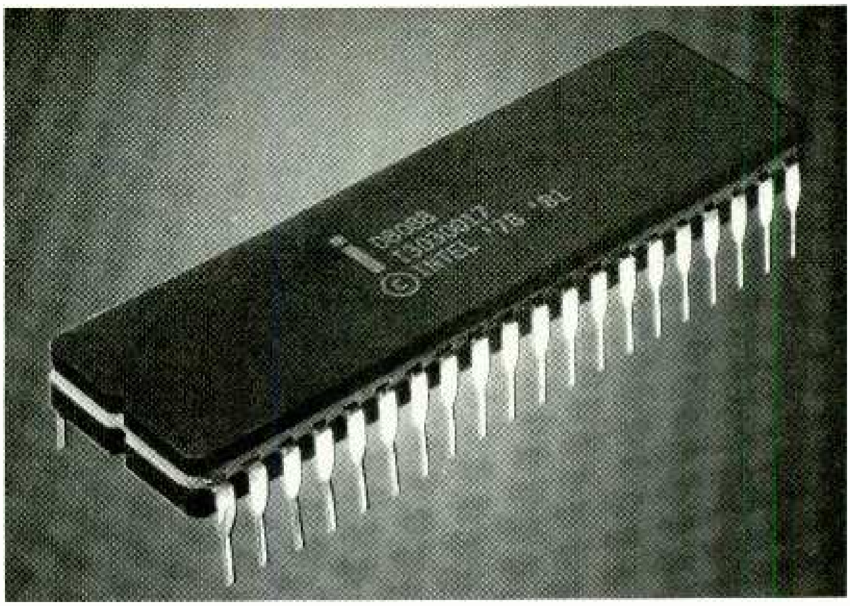
But even as the 8-bit market was developing, the era of the 16-bit computing loomed ahead. By 1978, Intel developed its first 16-bit CPU: the 8086. Then, in 1979, Intel found a way to multiplex the 16-bit data bus down to 8 bits, thereby allowing systems to be built less expensively. The 8088 contained 29,000 transistors, and was available in 5- and 8-MHz versions. Both the 8088 and the 8086 offered 20 address lines, which gave them a memory capacity of 1 megabyte—16 times more than the 64 kilobytes offered by the 8080, 6800, and 6502.

Motorola parried Intel by introducing the 68000, a true 16-bit CPU. Apple shortly abandoned the aging 6502 and used the 68000 in the Macintosh. Zilog attempted to stay in the 16-bit competition with the Z8000, but was unable attract interest from major computer manufacturers.

What helped Intel gain the prominence that it has today was IBM's selection of the 8088 for the original IBM PC, introduced in 1981. The PC made many compromises in the name of cost-effectiveness. Major functions including video and disk storage were stripped out and incorporated on separate plug-in boards. That in turn helped to create a huge market for peripherals. No one, including IBM, accurately forecast the impact the PC would have.

to be compatible with future OverDrive designs.

The Pentium has two 8-kilobyte caches—one for instructions and another for data. A dual-pipeline technique (known as *superscalar* architecture) allows the Pentium to process more than one instruction per clock cycle. Other substantial improvements include on-board power management (similar to the 486SL line). Currently the fastest released model runs at 100 MHz, and Intel has publicly demonstrated 150-MHz versions.



INTEL's 8088.

The Motorola family

Intel CPUs (and the computers built on them) capture the majority of customers and market share in the PC industry. Nonetheless, Motorola has also enjoyed an excellent reputation in the microprocessor arena. Motorola CPUs have long been—and continue to be—the microprocessor of choice for Apple's line of personal computers. Many embedded and high-performance computer designs have also carried Motorola CPUs. Table 2 summarizes features of the Motorola line of CPUs.

Motorola's initial microprocessor introduction was the 6800 in 1975. It was strictly an 8-bit processor capable of addressing 64 kilobytes of memory. Probably the most striking difference between the Motorola and Intel architectures is that early members of the 6800 family tended to minimize register usage in favor of general-purpose RAM.

Motorola introduced numerous variations of the 6800. The 6802 incorporated 128 bytes of RAM on the CPU itself. The 6803/6808 ran faster (3.58 MHz), incorporated 128 bytes of RAM, and included both a UART (universal asynchronous receiver/transmitter) for serial communications, and a counter/timer. The last variation of the 8-bit Motorola family was the 6809. It was similar to the 6802, but offered an enhanced instruction set, including what was probably the first multiply instruction on an 8-bit CPU.

Some of the earliest personal-computer kits were based on the 6800 family, and Tandy built a version of the Color Computer that was rather advanced (for its day) around a 6809. However, by 1978, the age of the 16-bit CPU had begun, and the second generation of personal computers that included the Apple Macintosh and the IBM PC would be 16-bit machines.

The 68000 family

In 1978 Motorola introduced its first 16-bit CPU: the 68000. Unlike Intel's 8086/8088, which could address only one megabyte of physical RAM, the 68000 had 24 address lines that could access 16 megabytes of RAM directly—it was an almost inconceivable amount of memory at the time. In addition, the 68000 ran faster than mainstream Intel processors of the day: 16 MHz. Also, Motorola abandoned

TABLE 2—MOTOROLA CPU FAMILY CHARACTERISTICS

CPU	Data Bits	Address Bits	Physical Address Space (Virtual)	Clock Speeds (MHz)	Notes	MIPS	Math Coprocessor
6800	8	16	64 K	2			
6802	8	16	64 K	3.58	128 bytes RAM		
6803/6808	8	16	64 K		128 bytes RAM + UART		
6809		16	64 K				
68000	16	24	16 MB	16		1.6 MIPS	6881
68020	32	32	4 GB	16, 33		5.5 MIPS	68882
68030	32	32	4 GB	16+–50	256 byte cache	12 MIPS	6882
68040	32	32	4 GB	25, 40	8 K cache	35 MIPS	Internal
68060	32	32	4 GB	50, 66	16 K cache	100 MIPS	Internal

the idea of RAM-based registers and incorporated 16 general-purpose registers in the 68000. It would be four years until Intel could approach the technology of the 68000.

Motorola entered the 32-bit CPU arena with the 68020. Like the 68000, the 68020 has 16 general-purpose registers, and can address four gigabytes of RAM directly. A first for the 68020 was the inclusion of an internal 256-byte instruction cache—negligible by today's standards, but a true architectural advance at the time.

The 68030 is Motorola's second-generation 32-bit CPU. It is very similar to the '020, but is available in faster speeds, and with one 256-byte cache each for data and instructions.

The 68040 is the third generation. It increases the data and instruction caches to 4 kilobytes each, and, for the first time, includes an on-board math coprocessor and memory-management unit.

One of the latest members of the 680x0 family is the 68060. The 68060 is a *superscalar* design that has multiple instruction pipelines, and on-board memory and power management.

PowerPC

After more than a decade of development, the 680x0 architecture simply ran out of steam, so Motorola teamed up with IBM and Apple to produce a new microprocessor with improved performance. The MPC601, or PowerPC, is a 64-bit superscalar CPU that can effectively execute up to three instructions per clock cycle. The PowerPC is the first implementation of reduced instruction set computing (RISC) for personal computers. (The 680x0 and 80x86 families use complex instruction set computing (CISC) technology.) With RISC, most instructions execute in only one clock cycle. Instructions can even be completed out of order, but the CPU will make them appear sequential. The MPC601 has a 32-bit address bus, 32 kilobytes of cache memory, and an internal math coprocessor. Apple appears to have bet its future hardware designs on the PowerPC architecture.

MICROPROCESSOR GLOSSARY AND NOMENCLATURE

Cache—A small amount of high-speed memory that stores information for immediate use by the CPU. Primary cache may be built into the CPU itself, and additional (secondary) cache may be available as fast static RAM.

CISC—Complex instruction set computing: Typified by complex instruction sets and address modes, and relatively expensive silicon. Compare RISC.

DLC—Suffix used by Cyrix for its 486SX-compatible CPUs. Cyrix's 486DLC is pin-compatible with the Intel 386DX and has only 1 kilobyte of on-chip cache, versus 8 kilobytes on an Intel 486.

DX—Intel suffix indicating several different features. The 80386DX supports a full 32-bit data bus, and the 80486DX contains an 8-kilobyte cache and a math coprocessor. Advanced Micro Devices also uses the DX suffix. Compare SX, DX2.

DX2—Intel suffix indicating that the CPU runs internally at twice the bus speed. For example, a DX2/50 runs at 50 MHz internally, but the memory interface runs at 25 MHz. Compare SX, DX.

DXLV—Advanced Micro Devices suffix for a low-voltage 386DX.

FPU—Floating point unit, also called a math coprocessor. A specialized IC designed to perform floating-point math more efficiently than an ordinary CPU.

MIPS—Millions of instructions per second, a relative measure of CPU performance. A higher value indicates a faster CPU.

OverDrive—Intel's trade name for its line of DX2 microprocessors.

Pentium—Intel's trade name for its fifth-generation microprocessor.

Pipelining—Design technique used to improve performance by allowing the processor to begin work on a subsequent instruction before completing the current instruction.

Power management—Circuitry that regulates the power consumption of a computer by effectively "turning off" power-hungry devices that are not being used.

RISC—Reduced instruction set computing: Typified by simple instruction sets and address modes, and relatively inexpensive silicon. Compare CISC.

SL—Intel suffix representing a low-power CPU (usually for mobile computers). The SL line has been canceled, and its features folded into more recent 486 and Pentium CPUs.

SX—Intel suffix with various meanings. Internally, the 80386SX supports a full 32-bit data bus, but externally, only 16 bits. The 80486DX allows the full bus width, but disables the internal math coprocessor. Compare DX, DX2.

SXL—Advanced Micro Devices suffix for a low-power SX CPU.

MICROPROCESSOR VENDORS

Cyrix
P.O. Box 853018
Richardson, TX 75085
(214) 994-8388

IBM Microelectronics
Route 100
Somer, NY 10589

Intel Corporation
2200 Mission College Blvd.
P.O. Box 58119
Santa Clara, CA 95052-8119
(408) 987-8080

Advanced Micro Devices
P.O. Box 3453
Sunnyvale, CA 94088-3453
(408) 732-2400

NEC Electronics, Inc.
475 Ellis Street
Mountain View, CA 94039
(415) 960-6000

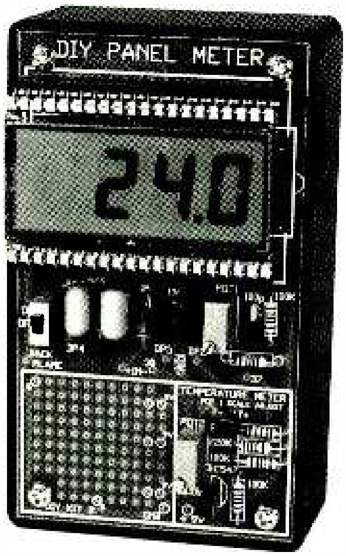
Motorola
3102 No. 56th Street
Phoenix, AZ 85018
(602) 244-6900

The clones

The huge microprocessor market has attracted other manufacturers who want to cash in. In the mid-1980's, NEC "cloned" the 8088 and 8086. More recently, American Micro Devices cloned Intel's 386 and 486 CPUs. AMD strategy was not to cut prices, but to improve performance. For example, when 33-MHz 386's dominated the market, AMD introduced its model running at 40 MHz. The company has continued that strategy.

More recently, several manufacturers, including AMD, Cyrix, and NexGen have jumped in to the fray, attempting to produce Pentium-class CPUs. None of these has been released yet, but several introductions are planned for this year. IBM has signed deals to manufacture CPUs for both Cyrix and NexGen, so it looks like choices are going to multiply rapidly. Ω

SOLID STATE THERMOMETER



Build an accurate, 3½-digit, handheld thermometer from a kit or from scratch.

MARC SPIWAK

THE LIQUID-CRYSTAL DISplay (LCD) and the single-chip analog-to-digital converter (ADC) have made possible an almost endless list of battery-powered, handheld test instruments. The most prominent of these are the digital multimeter (DMM) and the digital panel meter (DPM), but others include digital capacitance meters, thermometers, timers, sound-level meters, and light meters.

The single chip ADC eliminated a slew of discrete components and increased circuit reliability, while the LCD presents large characters that are easily seen in daylight. But of more importance in battery-powered instruments, both of these components are miserly in power consumption. This is especially important for battery conservation.

Within recent years the prices of single-chip ADC ICs and large-character LCDs have fallen, and they are now readily available as low-cost, off-the-shelf items from electronics stores and distributors.

The digital thermometer described here can be made from an available kit or the parts can be obtained from most electronics distributors. By building the thermometer, the builder will gain experience in working with advanced ICs and display modules, and at the same time gain insight into circuitry common to many different instruments.

The digital thermometer can make accurate, reliable, and repeatable temperature measurements in the laboratory or in the field over a wide range of temperatures. It will save money over the price of a factory-built instrument and, as a bonus, it provides circuit board space for adding extra components for experiments.

The basic digital thermometer circuit displays temperature in degrees Celsius to a an accuracy of a tenth of a degree on its 3½-digit LCD in half-inch high characters. The PC board can be purchased as part of the kit or made with the foil pattern included here. The electronic components are visible on the top surface of the instrument case, as shown in the illustration of the meter.

How does it work?

Figure 1 is a schematic for the digital thermometer. The key semiconductor device in the circuit is IC1, an ICL7106CPL single-chip analog-to-digital converter from Harris Semiconductor. It is a 3½-digit ADC with a built-in LCD display driver, BCD to seven-segment decoders, clock and voltage reference. The ADC is packaged in a 40-pin plastic DIP. In the digital thermometer described in this article, IC1 will be set to display 200 millivolts full scale (199.9), plus or minus.

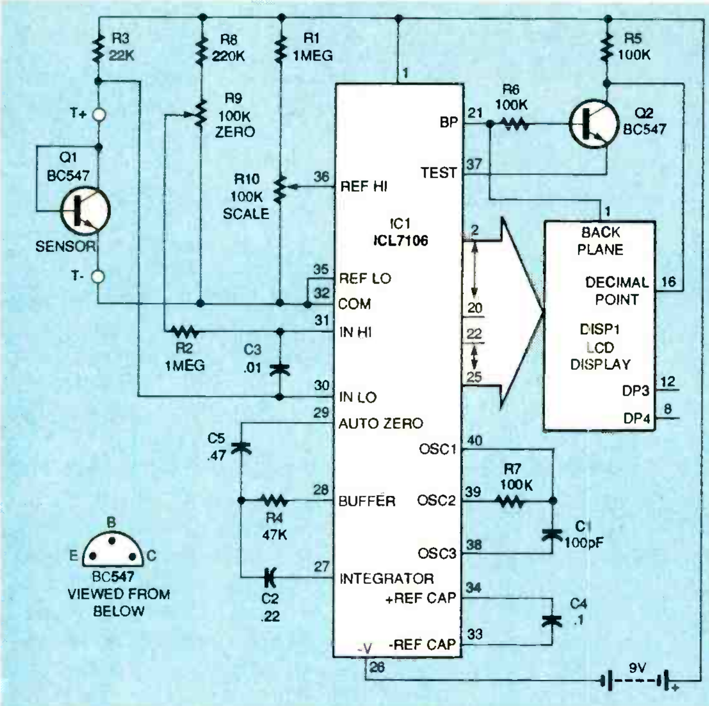
The temperature sensor for this digital thermometer is an NPN transistor modified to act like a silicon diode. The base of transistor Q1 is short-circuited to the collector, so it functions as a diode. However, it has a response curve that is more linear over a wider temperature range than a diode.

Transistor Q1 provides a variable input voltage to IC1. The voltage drop across the effective diode, typically about 0.7 volt, depends on the temperature of the diode's junction and the current flowing through it. The voltage drop is nearly linear, and will typically vary by 2.2 millivolts per degree Celsius.

A silicon diode has a negative temperature coefficient. Thus, in this application, as the temperature rises, voltage falls, and as the temperature falls the voltage rises. For example, if the ambient temperature rises by 2° Celsius, the voltage drop across the diode will decrease by about 4.4 millivolts. This linear voltage drop is measured to determine temperature.

The kit for the digital thermometer includes two transistors (Q1 and Q2) identified as BC-547s (but marked C547B). Pin identification is shown in Fig. 1. However, more readily available, industry-standard 2N2222 transistors can be substituted, although they have different pinout arrangements. Refer to the instructions given later if you want to make this substitution.

Trimmer potentiometers R9



IC1	DISP1
2	18
3	19
4	20
5	21
6	22
7	23
8	17
9	14
10	15
11	24
12	25
13	26
14	13
15	10
16	29
17	31
18	9
19	3
20	2
22	32
23	30
24	11
25	27

FIG. 1—SOLID-STATE THERMOMETER SCHEMATIC. The ICL7106 contains an analog-to-digital converter, BCD to 7-segment decoders, display drivers, a clock, and a reference voltage source.

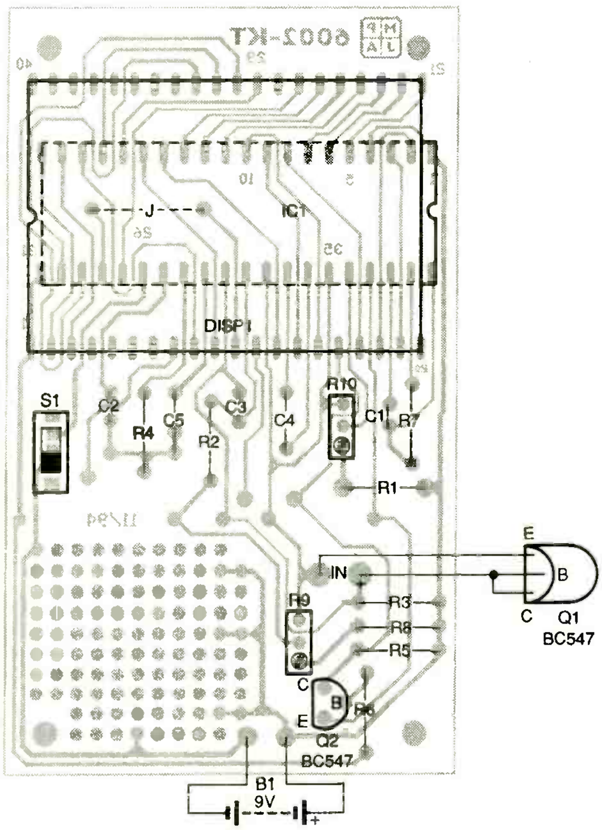
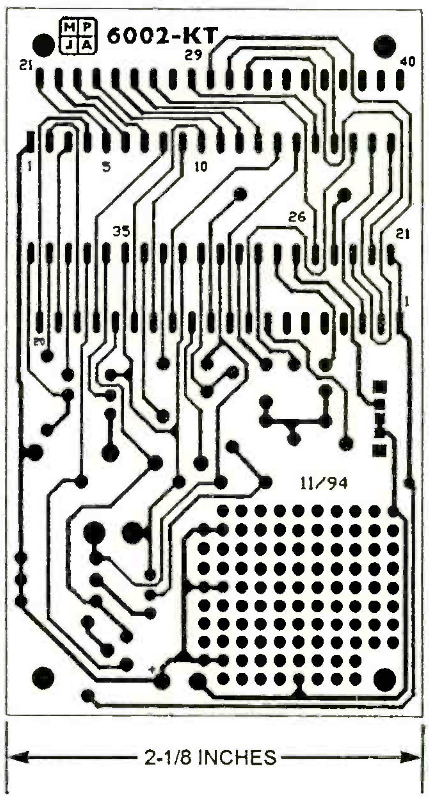


FIG. 2—PARTS-PLACEMENT DIAGRAM. IC1 is located beneath the liquid-crystal display module.



THERMOMETER FOIL PATTERN.

(ZERO control) and R10 (SCALE control) can be set to zero the meter and make scale adjustments in the input voltage to IC1. A display of 00.0 must correspond to zero degrees Celsius and the display temperature must increment in degrees Celsius. The multiturn potentiometers permit precise settings.

Because IC1 can also indicate the polarity of the input voltage, the digital thermometer is theoretically capable of displaying temperature measurements from −200 to +200 degrees Celsius. However, the transistor used as a temperature sensor and its leads could be damaged by those temperature extremes.

The digital thermometer is effectively a solid-state voltmeter that could be adapted for making other measurements such as voltage, current, power, light level, and sound intensity, and more. If the output of the sensor for the variable you want to measure can be scaled between 0 and 200 millivolts, the circuit presented here can display that variable in appropriate standard units with little or no circuit modification.

The PC board for this project contains a small space where additional components can be

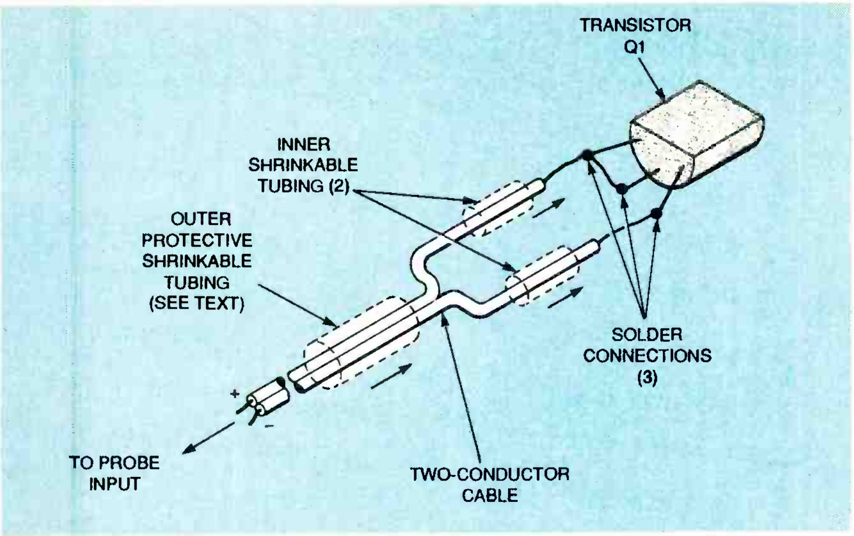


FIG. 3—THERMAL PROBE. The base and collector leads of transistor Q1 are bent together and soldered near the transistor's base and a two-conductor cable is attached.

PARTS LIST

All resistors are ¼-watt, 1%, unless otherwise noted.
R1, R2—1 megohm
R3—22,000 ohms
R4—47,000 ohms
R5–R7—100,000 ohms
R8—220,000 ohms
, R9, R10—100,000 ohms, potentiometer 10-turn PCB
Capacitors
C1—100 pF, polyester
C2—0.22 µF, polyester
C3—0.01 µF, polyester
C4—0.1 µF, polyester
C5—0.47 µF, polyester
Semiconductors
IC1— ICL7106CPL ADC, Harris or equiv.
Q1, Q2—BC547 NPN transistor (or 2N2222, see text and Fig. 5)
Other components
S1—slide switch, SPST, PCB-mount
DISP1—VI-302-DP-RC LCD module, 3½-digit, 40-pin package, Varitronix or equivalent)
Miscellaneous: PC board; three 40-pin IC sockets (see text); five machined pin sockets (optional); insulated hookup wire, 9-volt battery, battery clip with wires, project case with cover; miscellaneous hardware; solder.
Note: A kit for the digital thermometer (No. 6002-KT) can be purchased for $29.95 plus $4.00 for shipping and handling from Marlin P. Jones & Associates, Inc., P.O. Box 12685, Lake Park, FL 33403-0685, Phone: 407-848-8236, Fax: 407-844-8764.Florida residents please add local sales tax.

located and powered to perform experiments and make other kinds of measurements.

Figure 2 is the parts placement diagram for this meter. The circuit could be wired point-to-point, but that would call for a lot of wiring, especially in the display section. Consequently, the use of a PC board is recommended.

Insert all leaded components and sockets, and solder them in place on the solder side of the board. Insert resistor R1 and trimmer potentiometer R10 in individual machined pin sockets (two for R1 and three for R10) if you might want to replace those components with others having different values for different applications.

However, if you have no intention of experimenting with the finished meter, solder all resistors directly to the board. If you intend to substitute 2N2222 transistors, insert Q2 with its flat side opposite that shown in Fig. 2. More instructions on the substitution of 2N2222s will be given later.

Notice that analog-to-digital converter, IC1, is located under the LCD display, DISP1. When IC1 is installed, mount the LCD directly above it while orienting it to the opposite polarity (the notches are on opposite sides of the board). First install a socket for IC1. Then cut two 40-pin sockets apart along their long axes to provide four single inline (SIP) sockets. Insert one SIP socket within another to form two double-height SIP sockets. These will leave enough "headroom" for positioning IC1.

Solder the two double-deck SIP sockets to the board for DISP1, as shown in Fig. 2, and then install IC1. Then insert DISP1 in the double-height SIP sockets. This arrangement makes it easy to remove DISP1 by leaving the upper socket strips attached to the LCD and prying them away from the two lower socket strips that are soldered to the board. CAUTION: Do not attempt to remove the LCD from the upper sockets because the display pins can bend, and the glass body can break.

Cut a scrap of tinned lead wire to form jumper "J," insert and solder it. If you buy the digital thermometer kit, a case is included. The PC board fits securely in the top of the case to form a cover. Therefore, the inside the case provides enough space for the 9-volt battery. Solder the battery clip leads to the solder side of the board at the points shown in Fig. 2.

Refer to Fig. 3 and short-circuit QI's base lead to its collector lead near the body of the transistor by bending them together and soldering them. Slip short lengths of heat shrinkable tubing over each input end of a two-conductor cable. Solder the two shorted transistor leads to the positive sensor input wire and

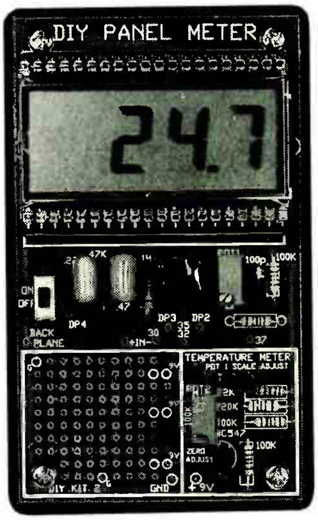


FIG. 4—THE TEMPERATURE-SENSING transistor can be located on the PC board, but leads must be attached for calibration.

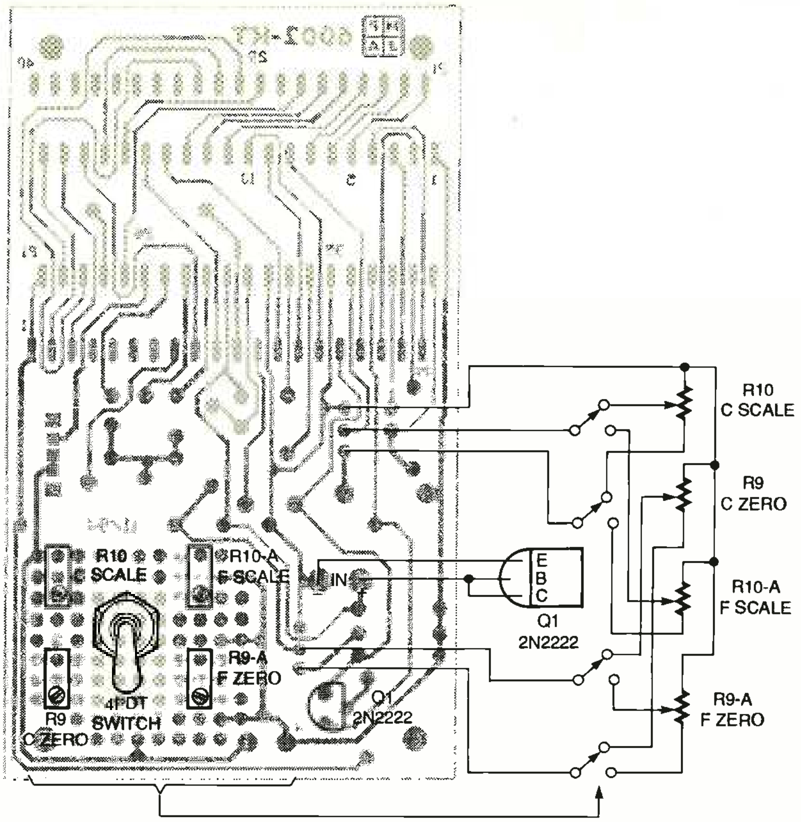


FIG. 5—THE CIRCUIT CAN BE MODIFIED as shown here to display part of the Fahrenheit scale in addition to the Celsius scale. Alternative 2N2222 transistors are installed as shown.

the emitter lead to the negative input wire.

Slip a short length of heat-shrinkable tubing on both leads and pull it over the end of the transistor to form an outer protective jacket, as shown in Fig. 3. Heat the tubing so that it forms a tight shrink fit around both the end of the transistor and the cable.

Standard insulated hookup wire leads are suitable for the temperature probe up to about 6 inches long. However, if the probe is to be mounted on leads longer than 6 inches, use thin shielded cable.

The temperature probe can also be mounted on the PC board directly with leads soldered to the "+" and "–" probe inputs. This arrangement will, however, make thermometer calibration more difficult. If you elect this option, temporarily attach the probe to the board with leads for calibration and mount it permanently to the board afterward. Figure 4 shows the completed digital thermometer.

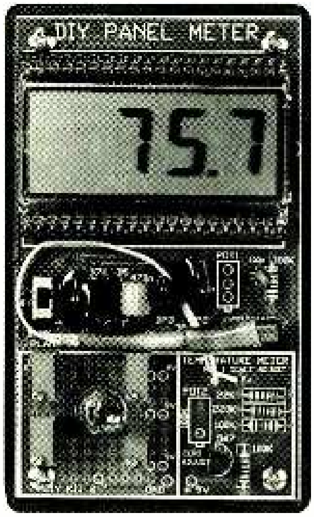


FIG. 6—MODIFIED THERMOMETER can display the full Celsius range and Fahrenheit from about 60° to about 80°.

Modifying the meter

As mentioned earlier, a small area on the PC board is set aside to accommodate components for experiments. We added two more potentiometers and a 4PDT switch to the circuit so the digital thermometer could be calibrated in Fahrenheit as well as Celsius degrees. Those modifications are shown in Fig. 5. The same figure also gives details for installing the alternative 2N2222 transistors, should you decide to substitute them.

Our tests showed that the meter's response is not perfectly linear for the Fahrenheit scale, and it is impossible to calibrate it at the boiling point of water because 212° cannot be displayed on the 3½-digit display. However, the response was linear enough for the display to give an accurate Fahrenheit reading from about 60 to 80°, the range in which most temperature readings are likely to be taken.

Calibrating the meter

Carefully inspect the circuit board for soldering errors and correct them before proceeding. If the board passes visual inspection, connect a 9-volt battery to it and switch on power. The display will either indicate a "1" or some other reading. If the display shows a "1," adjust potentiometers R9 and R10 to obtain a reading other than a "1."

Fill a container with ice cubes and add a small amount of water. Turn on the digital thermometer and submerge its temperature probe in the ice water, holding it in close contact with an ice cube. Wait until the display stabilizes and then adjust ZERO control potentiometer R9 until the display reads 00.0.

Boil water in a kettle and carefully hold the probe over the kettle spout in the steam with tongs to prevent accidentally scalding yourself. When the display reading stabilizes, adjust SCALE control potentiometer R10 until the display reads 100. If you have access to a digital multimeter with a temperature probe that is known to be calibrated, compare readings and adjust trimmers R9 and R10 more precisely.

If you added the Fahrenheit potentiometers, as shown in Fig. 5, calibrate the Fahrenheit scale next, bearing in mind the limitations discussed earlier. It is recommended that the tem-

Continued on page 53

WWV RECEIVER

Build this simple superheterodyne receiver to receive time and other useful signals from NIST's WWV and WWVH.

NEIL HECKT

BROADCASTING THE EXACT TIME OF day is just one of the many services provided by radio stations WWV and WWVH operated by the National Institute of Standards and Technology (NIST). Their ultra-accurate 10-megahertz carrier frequencies can be used to calibrate signal generators in a process called "zero beating" against the carrier frequency. The stations also transmit many other accurate frequencies, storm warnings for mariners at sea, and GPS (Global Positioning Satellite) position data.

This article explains how to build a simple, inexpensive superheterodyne radio receiver for WWV and WWVH signals. The objective in the design of this receiver was to obtain reliable reception with an antenna only 3- to 6-feet long. The sensitivity obtained with this receiver equals that obtainable from a $1000 communications receiver operating from a 60-foot antenna.

Can the performance of a receiver made from $30 worth of parts equal the performance of a $1000 factory-built receiver? The answer is no because sensitivity is only one measure of receiver performance. The most significant difference between receivers is in their overall signal-to-noise ratios. However, the WWV/WWVH receiver described here has sufficient sensitivity to achieve its dedicated function.

This receiver economizes in the quality of its filters. Most factory-made communications receivers contain expensive precision crystal intermediate frequency (IF) filters which greatly improve the signal-to-noise ratio by screening out most of the noise in the radio-frequency spectrum. Moreover, those communications receivers also have superior intermodulation distortion (IMD) and dynamic range not required for WWV/WWVH reception.

WWV/WWVH transmissions

The WWV transmitter is located in Fort Collins, Colorado, and its signal can be identified by male voice announcements.

TABLE 1—UTC TIME ZONE CONVERSION

UTC	Eastern	Central	Mountain	Pacific Alaska	Alaska Hawaii
0000	7:00PM	6:00PM	5:00PM	4:00PM	2:00PM
0100	8:00PM	7:00PM	6:00PM	5:00PM	3:00PM
0200	9:00PM	8:00PM	7:00PM	6:00PM	4:00PM
0300	10:00PM	9:00PM	8:00PM	7:00PM	5:00PM
0400	11:00PM	10:00PM	9:00PM	8:00PM	6:00PM
0500	Midnight	11:00PM	10:00PM	9:00PM	7:00PM
0600	1:00AM	Midnight	11:00PM	10:00PM	8:00PM
0700	2:00AM	1:00AM	Midnight	11:00PM	9:00PM
0800	3:00AM	2:00AM	1:00AM	Midnight	10:00PM
0900	4:00AM	3:00AM	2:00AM	1:00AM	11:00PM
1000	5:00AM	4:00AM	3:00AM	2:00AM	Midnight
1100	6:00AM	5:00AM	4:00AM	3:00AM	1:00AM
1200	7:00AM	6:00AM	5:00AM	4:00AM	2:00AM
1300	8:00AM	7:00AM	6:00AM	5:00AM	3:00AM
1400	9:00AM	8:00AM	7:00AM	6:00AM	4:00AM
1500	10:00AM	9:00AM	8:00AM	7:00AM	5:00AM
1600	11:00AM	10:00AM	9:00AM	8:00AM	6:00AM
1700	Noon	11:00AM	10:00AM	9:00AM	7:00AM
1800	1:00PM	Noon	11:00AM	10:00AM	8:00AM
1900	2:00PM	1:00PM	Noon	11:00AM	9:00AM
2000	3:00PM	2:00PM	1:00PM	Noon	10:00AM
2100	4:00PM	3:00PM	2:00PM	1:00PM	11:00AM
2200	5:00PM	4:00PM	3:00PM	2:00PM	Noon
2300	6:00PM	5:00PM	4:00PM	3:00PM	1:00PM

(add one hour during daylight savings time)

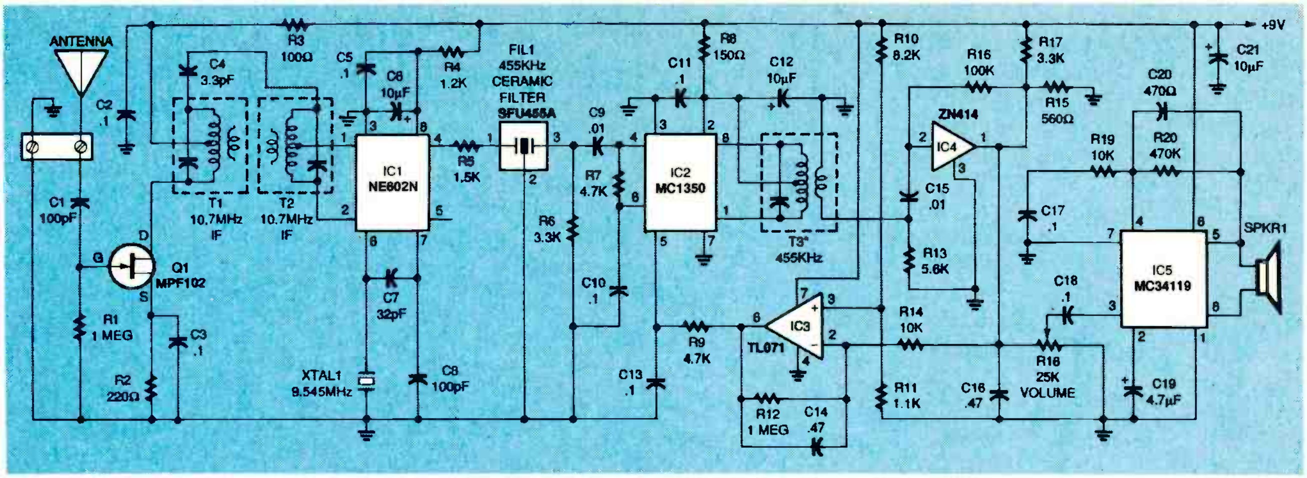


FIG. 1—SCHEMATIC OF THE WWV RECEIVER. A short antenna from three to six feet long is sufficient.

WWVH's transmitter is located in Kauai, Hawaii, and its signal can be identified by female voice announcements. Both stations broadcast on exactly the same frequencies, but they do not interfere with each other because their bands are so narrow they sound like a single station when both are received with equal signal strength.

Stations WWV and WWVH operate on a carrier frequency of 2.5 MHz. Station WWV broadcasts with 2.5 kilowatts (kW) of power, while WWVH broadcasts with 5 kW of power. Other frequency-power relationships are 5, 10, and 15 MHz at 10 kW and 20 and 25 MHz at 2.5 kW. The receiver described in this article was designed to receive 10-MHz signals because the author has found that they provide the most reliable reception.

Carrier frequency and all other time-related data is derived from cesium-controlled oscillators that are accurate to within ±1 part in 10^{11}. Daily deviations are less than one part in 10^{12} from day-to-day. Phenomena such as Doppler and diurnal shifts can degrade the accuracy at the receiver, but long-term accuracy of one part in 10^9 can easily be obtained.

There are many different time zones around the world, so it would be impractical to broadcast time for each time zone. To simplify matters, WWV/WWVH transmit time data in *Coordinated Universal Time* (UTC), also known as Greenwich Mean Time (GMT), World Time and Zulu Time.

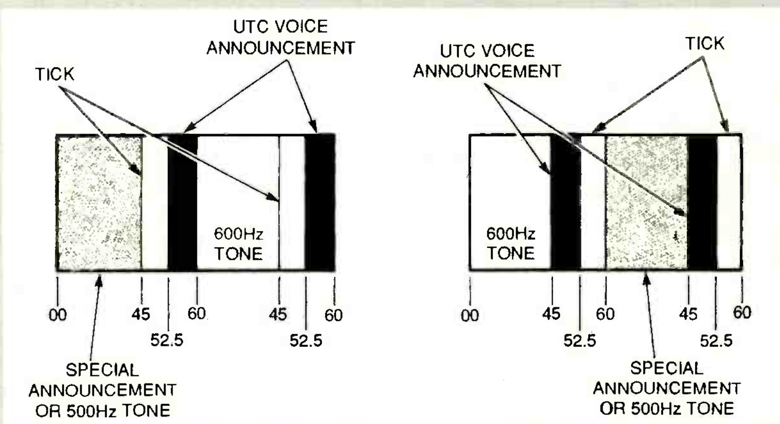
What is UTC? It is the time in England, uncorrected for daylight savings time, and it is always stated in a 24-hour format. It is called GMT because the zero or Greenwich meridian passes through England, west of London. Table 1 provides information that will permit you to determine the local time-of-day from the UTC announced by WWV and WWVH.

Refer to the sidebar for more technical details on the WWV and WWVH transmission formats. More information on the services of WWV and WWVH can be obtained by writing Frequency-Time Broadcast Services Section, Time and Frequency Division, National Institute of Standards and Technology, Boulder, CO 80302.

Circuit description

A schematic of the WWV receiver is shown in Fig. 5. A short antenna (three to six feet) represents a high-impedance source. Transistor Q1, a Motorola

WWV and WWVH minute signals



WWV and WWVH each have different one minute increments of time, as shown. Minute zero, and all even numbered minutes of WWV begin with a 45-second interval containing either a special announcement or a 500-Hz tone. This is followed by 7.5 seconds of silence except for the one-second *tick*.

The last 7.5 seconds contains the voice UTC time announcement. Minute 1, and all odd numbered minutes, have 45 seconds of a 600-Hz tone followed by the 7.5 seconds of silence except for tick and the 7.5-second UTC time announcement.

WWVH broadcasts with a similar format except even and odd minutes are reversed, and the silent and UTC time announcement intervals are reversed. This prevents interference if both stations are received simultaneously (this occurs on the West Coast of the U.S.). The 45-second interval of each minute might contain variations.

MPF102 JFET, provides input impedance matching and some gain. A double-tuned input filter, consisting of T1, T2, and C4, provides adequate selectivity to attenuate the image frequency of 9.09 MHz.

A Philips NE602N mixer (IC1) contains a double-balanced mixer and oscillator which supplies approximately 14 dB of conversion gain. The oscillator section is crystal controlled to provide stability and eliminate the need for tuning. The output of the NE602N is coupled to a 455-kHz ceramic IF filter (FIL1) with about a 6-kHHz bandwidth. The filter's 3000-ohm input and output impedance is matched by resistors R5 and R7. The output impedance of IC1 is 1500 ohms which, with R5, equals about 3000 ohms.

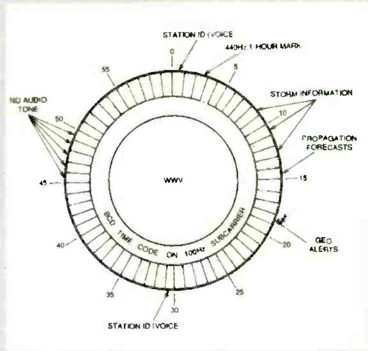
A Motorola MC1350P IF amplifier (IC2) provides about 60 dB of gain with about 80 dB of automatic gain control (AGC) control range. The output is coupled through 455-kHz IF transformer T3. The output impedance of IC2 at 455 kHz is about 200 kilohms. Transformer T3 has a turns ratio of 6:1, and it provides an impedance transformation of 36:1.

Resistor R13 terminates the secondary of T3 with 5600 ohms, to provide the proper primary matching impedance. Other turns ratios can be used for T3 provided that R13 is also changed to maintain the proper impedance match. The input impedance of IC4 is high and it does not significantly affect the impedance match.

The GEC Plessey ZN414Z, an amplifier detector, is packaged in a typical plastic transistor case, but it is actually a ten-transistor IC which provides about 70 dB of gain, detection and some AGC response. It is designed to be powered from a 1.5-volt DC power supply with a 500-ohm load. This is emulated by resistors R15 and R17 whose equivalent circuit is 1.5-volts DC flowing through 500 ohms. The DC level at the output of IC4 is about 1.1-volts DC with no signal, and 0.9-volt DC with a strong signal.

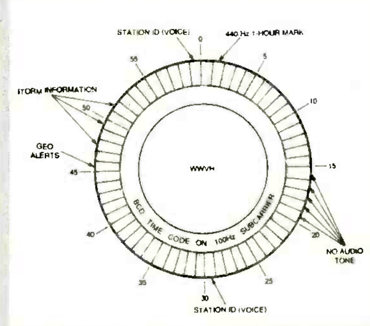
The output signal is amplified, inverted, and filtered by IC3. Capacitor C14 removes any audio from the signal before it is applied to the gain control input

WWV hour signals



The figure shows how the WWV hour is divided. The beginning of each hour is identified by a 0.8-second,1500-Hz tone. The beginning of each minute is identified by a 0.8 second,1200-Hz tone. The 29th and 59th second pulse of each minute is omitted.

WWVH hour signals



The figure illustrates how the WWVH hour is divided. The beginning of each hour is identified by a 0.8-second, 1500-Hz tone. The beginning of each minute is identified by a 0.8-second, 1200-Hz tone. The 29th and 59th second pulse of each minute is omitted.

WWV and WWVH broadcasts are approximate mirror images of each other. This prevents the two stations from creating interference mutual interference during voice announcements.

PARTS LIST

All resistors are ½-watt, 5%, unless otherwise noted.
R1, R12—1 megohm
R2—220 ohms
R3—100 ohms
R4—1200 ohms
R5—1500 ohms
R6, R17—3300 ohms
R7, R9—4700 ohms
R8—150 ohms
R10—8200 ohms
R11—1100 ohms
R13—5600 ohms
R14, R19—10,000 ohms
R15—560 ohms
R16—100,000 ohms
R18—25,000 ohms, potentiometer PCB-mount
R20—470,000 ohms

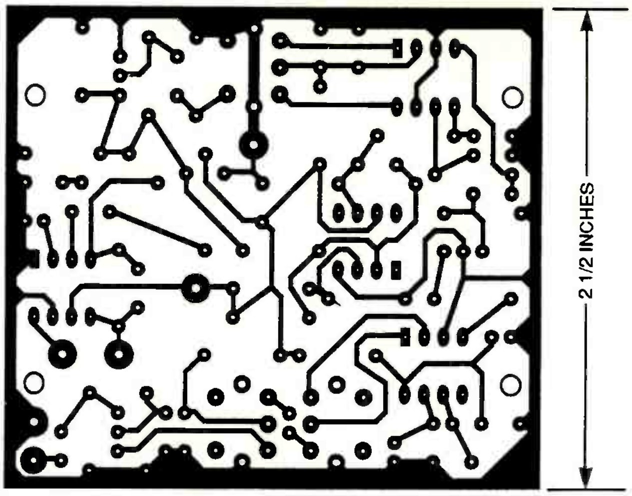
Capacitors
C1, C8—100 pF, ceramic
C2, C3, C5, C10, C11, C13, C17, C18—0.1 µF, ceramic
C4—3.3 pF, ceramic
C6, C12, C21—10 µF, 10 volts, aluminum electrolytic
C7—33 pF, ceramic
C9, C15—0.01 µF, ceramic
C14, C16—0.47 µF, ceramic
C19—4.7 µF, 10 volts, aluminum electrolytic
C20—470 pF, ceramic

Semiconductors
IC1—NE602AN mixer, Philips or equiv.
IC2—MC1350P IF amplifier, Motorola or equiv.
IC3—TL071 operational amplifier, Texas Instruments or equiv.
IC4—ZN414Z amplifier/detector (GEC Plessey)
IC5—MC34119P power amplifier, Motorola or equiv.
Q1—MPF102 JFET, Motorola or equiv.

Other components
FIL1—455-kHz ceramic filter,SFU455A or equiv.
T1, T2—10.7-MHz IF transformer (Toko or equivalent)
T3—455-kHz IF transformer, 6:1 ratio (Toko or equivalent)
XTAL1—9.545-MHz crystal
SPKR1—speaker, square, 2.5-inch, 8-ohms
S1—SPDT switch, PCB mount
Miscellaneous: 5.3 × 4 × 2-inch plastic project case, PC board, 9-volt battery, battery clip, hookup wire, solder.

Note: The following items are available from Almost All Digital Electronics, 1412 Elm Street S.E., Auburn, WA 98092:
- **Complete kit—$36.95 + $4.00 S&H**
- **Partial kit (includes all electronic components, PC board, and crystal—does not include project case, speaker, or antenna)—$24.95 + $4.00 S&H**
- **PC board and crystal, only—$10.00 + $2.90 S&H**
- **Case and speaker, only—$10.00 + $2.90 S&H**
- **Antenna—$3.00 + $2.90 S&H**
- **Fully assembled unit—$45.95 + $4.00 S&H**

Send check or money order. Washington State residents add local sales tax.



WWV RECEIVER FOIL PATTERN.

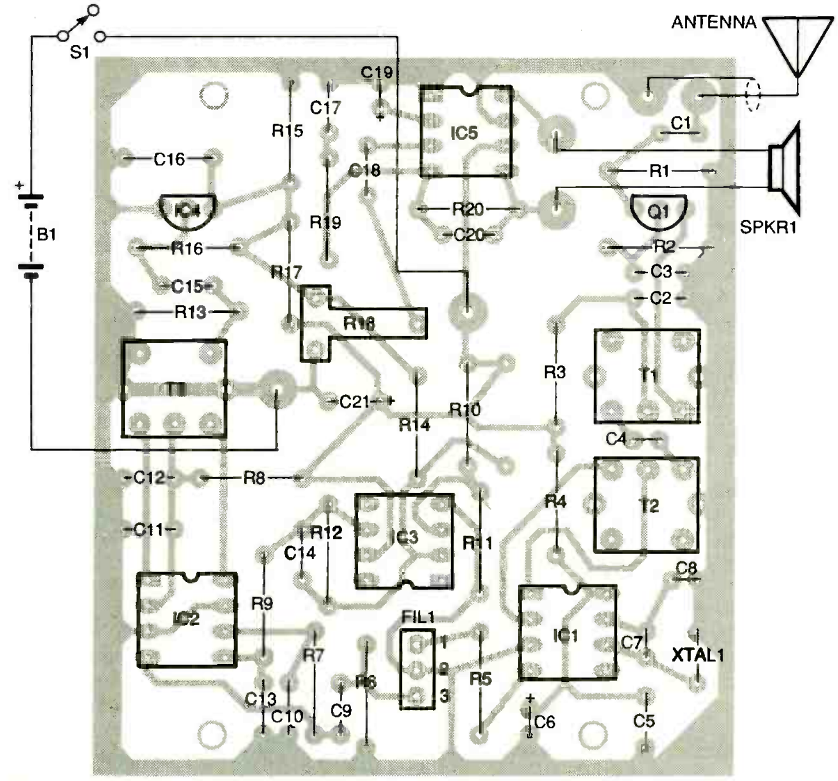


FIG. 2—PARTS-PLACEMENT DIAGRAM. The volume control is mounted on the PC board and adjusted before closing up the case.

pin 5 of the Motorola MC1350P IF amplifier (IC2). When the voltage at the output of IC4 exceeds the 1-volt DC reference level set by R10 and R11, the gain of IC2 starts to roll off. As a result, the AGC response of IC2 and IC3 tries to maintain the signal level so that the DC level at the output of IC4 is 1-volt DC.

The gain of the Motorola MC34119P audio amplifier (IC5) is set by the ratio of R20 to R19, which equals 47 (about 16 dB). This audio amplifier was selected because it is a bridge amplifier and does not require a large coupling capacitor to drive the speaker.

The overall maximum gain of the receiver is about 144 dB. This is the sum of a −10 dB in the input filter, +14 dB from IC1, −6 dB in FIL1, +60 dB from IC2, +70 dB from IC3, and +16 dB from IC4. Ordinarily a gain of 144 dB is too much. Normal operation can be expected to be with about a 120 dB maximum gain, which is typical of a high-quality communications receiver. However, the gain is usually less than that, as set by the volume-control potentiometer R18 and AGC loop.

Building the receiver

You can build the receiver on a single-sided PC board that you make yourself from the foil pattern provided here. Alternatively, partial and complete kits containing a finished PC board, as well as complete receivers, are available from the source given in the Parts List.

Figure 6 is a parts-placement diagram. The order of assembling the components to the circuit board and soldering them is not critical. Pay particular attention to the orientation of the semiconductors, that is the location of pin 1. Mount the volume control on the PC board. Keep in mind that it cannot be adjusted after it is installed in the case.

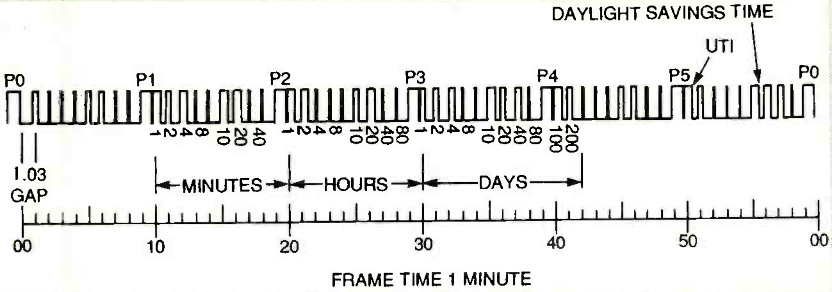
The author designed the circuit assuming that the receiver would be turned on only for brief periods to obtain the correct time, and that convenient access to the volume control would not be necessary. However, if you want an external volume control, one can be mounted on the case and wired directly to the pads intended for the PCB-mounted control.

After all the electronic components are inserted and soldered to the circuit board, wire the speaker, battery clip, power switch, and antenna. Install the completed circuit board in the case as shown in Fig. 7. Install a 9-volt battery.

Circuit alignment

To align the circuit, adjust transformers T1, T2, and T3 for peak AGC voltage at pin 6 of IC3. The desired tuning is broad for receiving a strong signal. Attach an antenna that is as short as practical to pick up an extremely weak signal for the alignment procedure. Even with those precautions, the tuning range of the IF transformers will appear to be quite broad.

Dividing Up Time For Broadcast



The figure illustrates the pulse format for the BCD time code (100-Hz subcarrier). During the passage of a minute, both stations broadcast the time of year on a pulse-width modulated 100-Hz subcarrier. Three different pulse widths are used:

1. P0-P5—position identifiers—0.8 seconds (80 cycles)
2. Logic 1—data bit—0.5 seconds (50 cycles)
3. Logic 0—data bit— 0.2 seconds (20 cycles)

In addition there is a 1.03 second (103 cycles) "hole" in the code for synchronization at the beginning of each minute signal. The minute is divided into six parts of 10 seconds duration. Each part consists of nine data bits and a position identifier pulse. The following listing is the contents of the various sections.

1.—Synchronization "hole" and eight logic zeros.
2.—Four data bits encoding the unit minutes in binary-coded decimal (BCD), a logic 0, three data bits encoding the tens of minutes in BCD and another logic 0.
3.—Four data bits encoding the unit hours in BCD, a logic 0, and two data bits encoding the tens of hours in BCD and two logic 0's.
4.—Four data bits encoding the unit days in BCD, a logic 0, and four data bits encoding the tens of days in BCD.
5.—Two data bits encoding the hundreds of days in BCD and seven logic 0's.
6.—One data bit if UT1 correction should be applied, four logic 0's, a data bit which is logic 1 if daylight saving time and three data bits with the UT1 correction in tenths of a second. The UT1 correction accounts for the Earth's rotation which varies slightly over time.

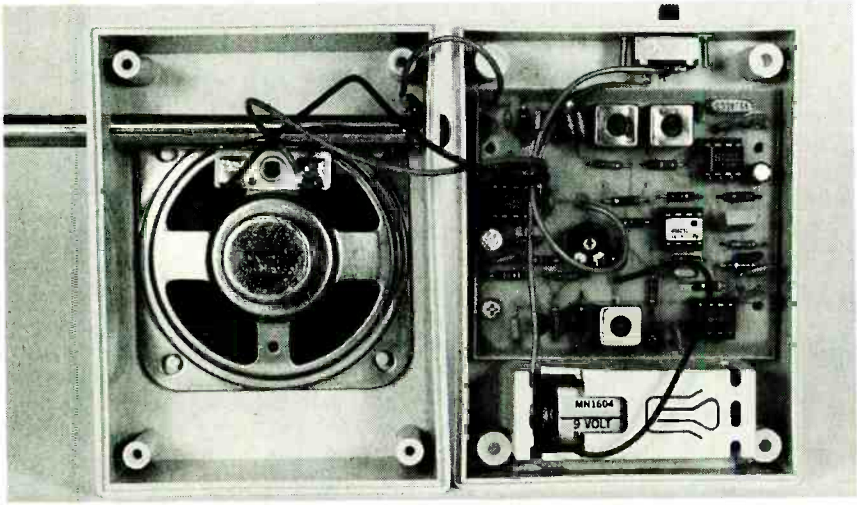


FIG. 3—THE FINAL ASSEMBLY consists of wiring the speaker, battery clip, power switch, and antenna. The author's prototype is shown here.

As an alternative to "on-air tuning," set up a 10-megahertz signal source. It will make the task of circuit alignment easier by providing a constant, local, easy to control signal. The author set a frequency counter at 10-megahertz and its internal oscillator provided sufficient ambient signal leakage to act as an excellent signal source for alignment.

The most difficult step is the alignment of the double-tuned input filter, T1/T2. To overcome that obstacle, all of the transformers that are supplied with the kit from the source listed in the Parts List are pre-aligned. Only slight adjustments are then necessary for the transformers after assembly.

Antenna considerations

The author lives near Seattle, Washington—about 1000 miles from Fort Collins, Colorado. Moreover, there are several mountain ranges between Seattle and Fort Collins. The quality of reception is usually excellent during the day with an antenna consisting of a 3- to 6-foot length of wire. When the signal is particularly strong, no antenna is needed.

The prototype receiver shown in the photographs has a 30-inch telescopic rod antenna that works quite well, but this a convenience feature rather than a requirement. There are two pads on the board for the connecting the antenna: one is connected to the antenna and the other is the ground connection. While a single wire on the antenna terminal usually works well, reception can generally be improved with a simple dipole antenna formed by a second wire connected to ground. Ω

THERMOMETER

continued from page 48

perature of ice water (32°F) and 80°F water be the test points.

The temperature of the hot water can be determined accurately with a standard laboratory mercury thermometer, but a high-quality, liquid-filled confectioner's thermometer will also give satisfactory results.

Measuring temperature

Observe common sense precautions when measuring temperature with your digital thermometer. If the transistor/sensor is held near an open flame or heating coil it will be damaged or destroyed.

If you put the digital thermometer in a protective case to protect it from dust, rain, and salt spray, it will work reliably out of doors, in boats, or even on camping trips.

Keep the digital thermometer's temperature measurement limits in mind. The Harris ICL7106CPL has a rated temperature range of 0 and 70° Celsius. Ω

PROTOTYPING STATION

Build this full-featured breadboard laboratory, and add custom features to suit your own needs.

ONE OF THE MOST GRATIFYING BENefits of being an electronics hobbyist is the opportunity to design and build custom projects for a particular need or purpose. The incredible number of new integrated circuits that are introduced each year provides building blocks for circuits and fertile ground for experimentation in electronics.

One requirement for successful prototyping and experimentation is a quick, convenient way to connect and disconnect components. Solderless breadboards are a good start, but all too often one is likely to end up with the board in the center surrounded by a maze of wires that connect switches, potentiometers, meters, power supplies, and any number of other components that dangle in all directions. The arrangement of components can be both frustrating and irritating. The solution is to combine the breadboard, power supply, and other commonly used parts into a self-contained unit.

Factory-made laboratories like that are available, but they can be quite expensive. The lab described in this article, however, combines economy, expansion, and easy customization—you can use many of the parts you might already have on hand in your junkbox.

Design

The prototyping station base consists of a 20-inch length of 1- by 12-inch pine board that is sanded, stained and finished. The various power supplies are located to the right; the center section is reserved for three breadboards and the main equipment backboard. The left side is left open to accommodate additional modular backboards, or any other peripherals such as keypads or data-entry terminals. The base can be raised to make room for plastic drawers, power transformers, or other equipment. Rubber feet can be used to ensure that the lab is stable on the bench. That basic layout is shown in Fig. 1.

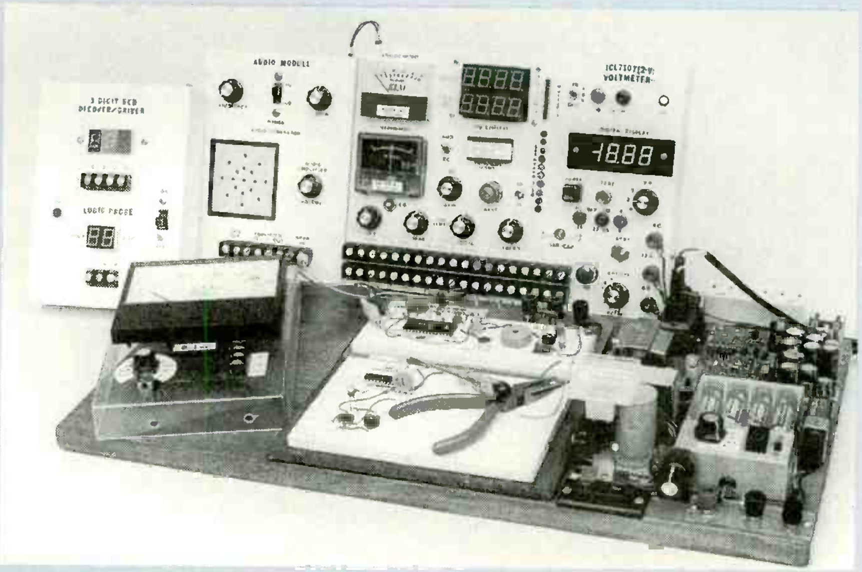


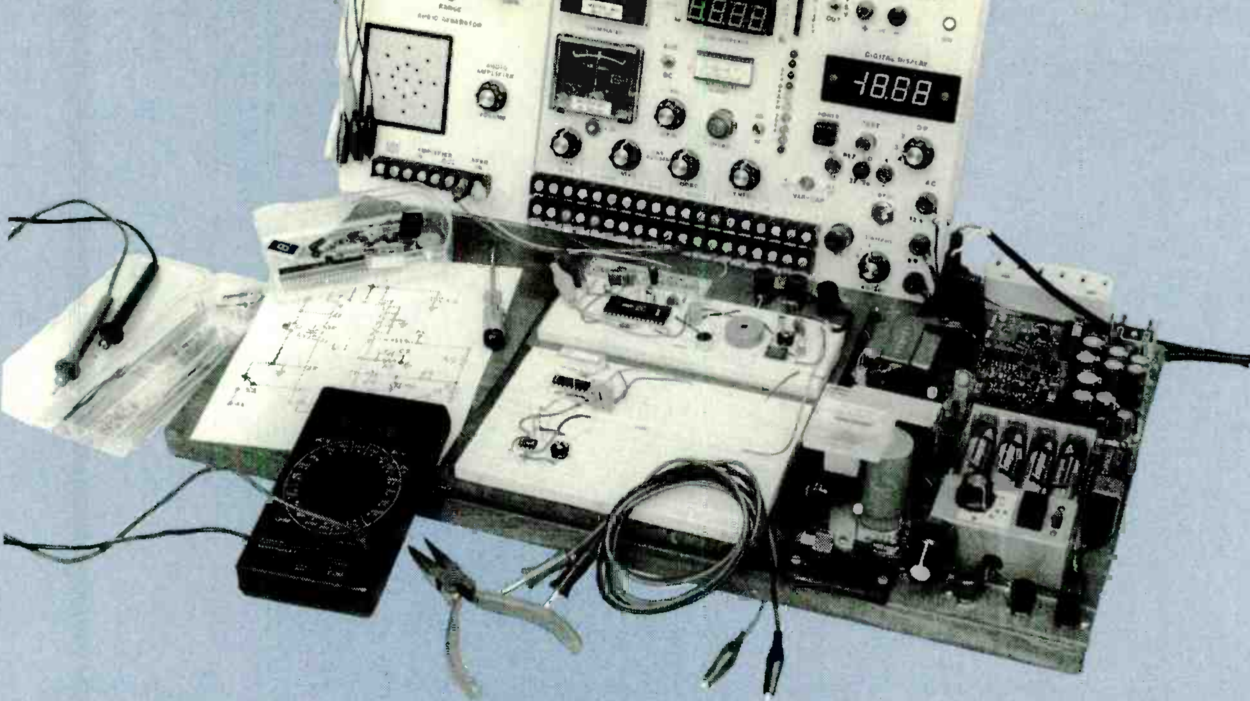
FIG. 1—BASIC PROTOTYPING LAYOUT. The base can be raised to make room for plastic drawers, power transformers, or other equipment.

Power supplies

Since the availability of power is always a requirement for successful prototyping, a variety of different power sources is incorporated on the right-hand section of the station (Fig. 2 shows a close-up view of the power section). The first power supply on the upper left is a surplus Texas Instruments computer board, bought at a clearance sale for $5. With the addition of an LED indicator, it provides a good clean source of ±5 volts and +12 volts. Being a computer-grade supply, the outputs are well-regulated, well-filtered, and can output about 1 ampere each. Power for this supply comes from an off-board wall-outlet transformer, and it is input to the supply via a two-position pushbutton terminal (the kind you might see on the back of a speaker).

Since a standard dry cell is appropriate to power many circuits, the second supply shown on the upper right of Fig. 2 consists of four AA cells and one 9-volt battery. The case from an old nickel-cadmium battery charger holds the AA cells, and a rotary switch and power indicator were added. The battery holder is tapped at each of the four positive battery pads, and each pad is wired to one pole of the rotary switch. The 9-volt battery is wired to a fifth pole on the rotary switch. This allows the selection of 1.5, 3, 4.5, or 6 volts DC from the AA pack, and 9 volts from the 9-volt battery. The LED indicator is a 0.3-inch

CARL J. BERGQUIST



high, seven-segment display, with all segments turned on to form an "8," which is a more noticeable reminder of the "on" status of the battery pack than a single LED. The output from this supply is connected to two of three binding posts for easy access. The third binding post is the negative 5-volt supply from the TI computer supply.

Another voltage source is provided by a +1.2- to 20-volt DC variable power supply that was built from a kit some years ago. The potentiometer next to the battery pack allows for adjustment of the output voltage, which is available at another two-position pushbutton terminal. An analog meter indicates the voltage at the pushbutton terminals.

Next to the variable supply is a 12.6-volt, center-tapped transformer, complete with a switch and indicator LED, that provides 6- and 12-volts AC. An SPST slide switch is connected to one side of the 120-volt AC input to the transformer primary. The outputs are wired to multipurpose posts on the main backboard.

AC power is made available at a triple-outlet AC strip, which gets its power via a heavy-duty line cord. The power inputs for the AC and variable supplies are also connected to this line cord.

The five separate power supplies can be customized to suit your needs. If you decide to enclose the power supplies, be sure to provide for adequate ventilation to allow heat to escape. The main 120-volt AC input should be protected against surges and spikes if you anticipate prototyping computer circuits.

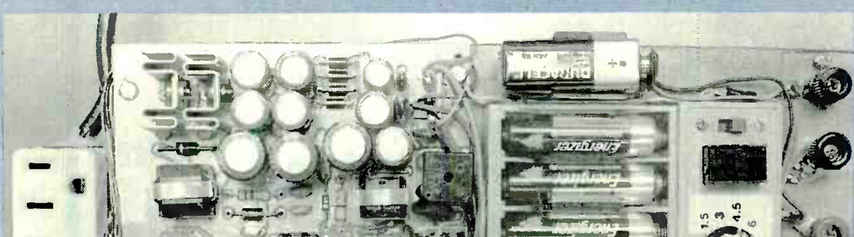
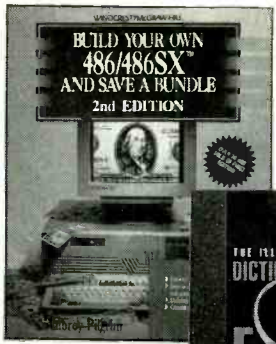


FIG. 2—A VARIETY OF POWER SOURCES is incorporated into the lab.

Breadboards

In the center of the base board are three 640-point solderless breadboards, laid out side-by-side (see Fig. 3). The top breadboard is a Radio Shack unit on a metal base with three multipurpose posts. The other two breadboards are plug-in panels mounted on a plywood base. All three breadboards have dual two-connection bus lines at their tops and bottoms, and will accommodate SIPs, DIPs, dis-



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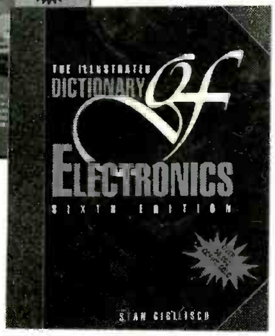

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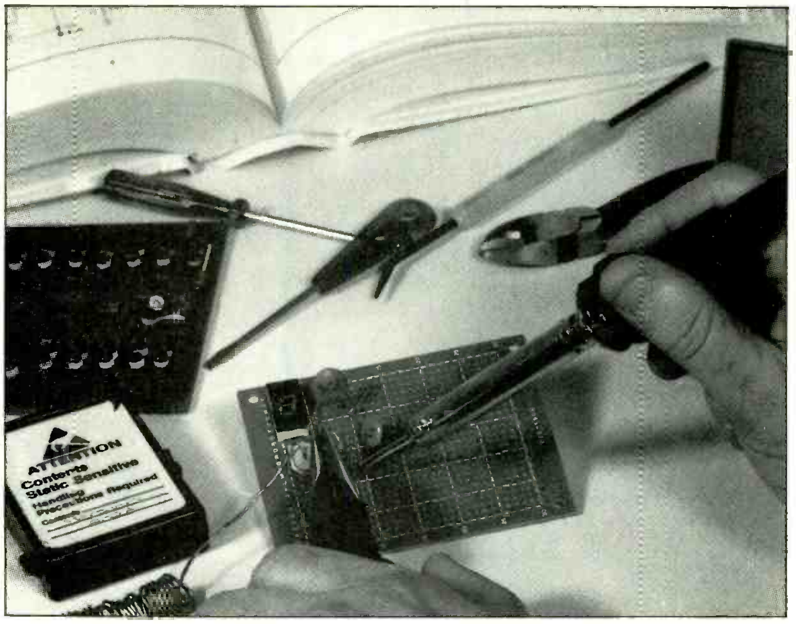

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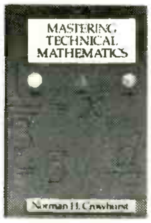

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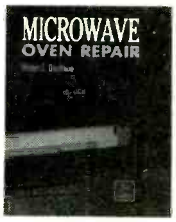

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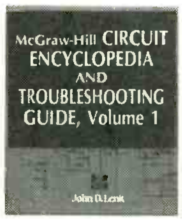

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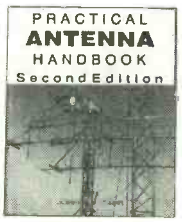

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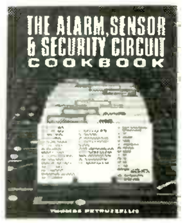

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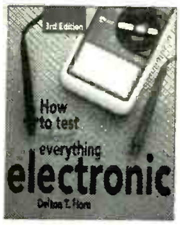

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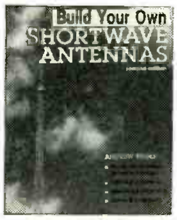

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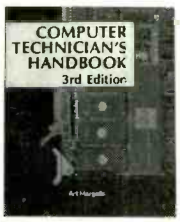

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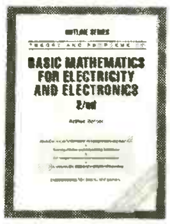

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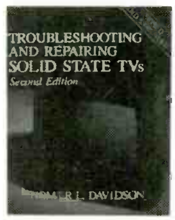

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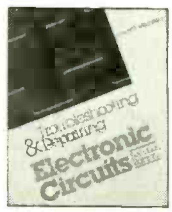

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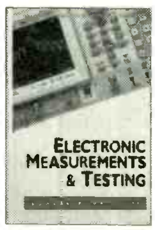

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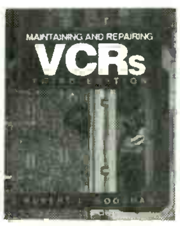

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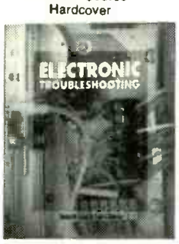

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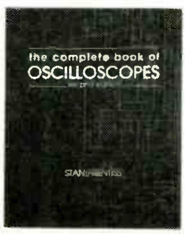

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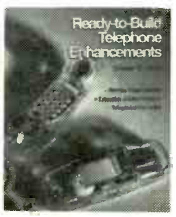

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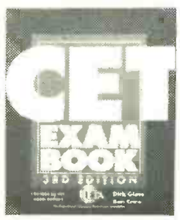

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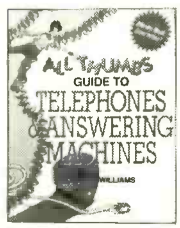

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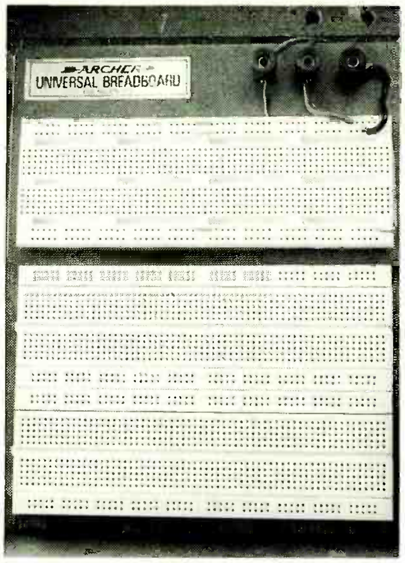


FIG. 3—THREE 640-POINT breadboards are laid out side-by-side. The top breadboard is on a metal base with three multipurpose posts, and the other two are plug-in panels mounted on a plywood base.

crete components, and jumper wires. While this breadboard arrangement has provided the author with enough space and has been versatile enough for all of his projects to date, it is certainly not the only arrangement possible. The breadboards are available in a variety of shapes and sizes, with from 250 contact points to 2500 or more. Some thought about the types of circuits you'll be working on will help you make a final decision on this part of the lab.

Backboards and modules

The main function of the backboard is to support more cumbersome components, modules, and any other circuits that the builder wants to add—items such as switches, potentiometers, meters, displays. The main backboard occupies about 10 inches across the back edge of the base (see Fig. 4).

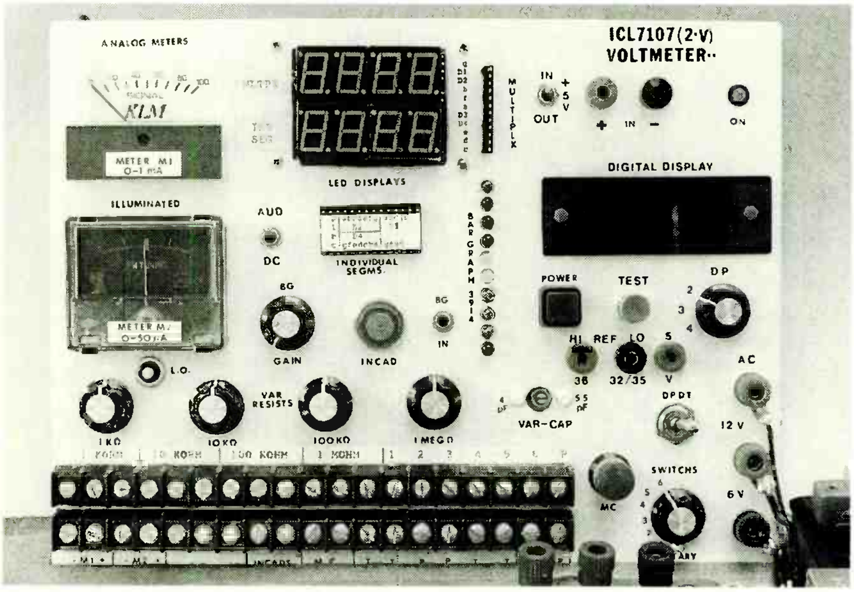


FIG. 4—THE MAIN BACKBOARD occupies about 10 inches across the back edge of the base. The backboard holds many of the accessories.

Two 19-position terminal strips provide access to the parts mounted on the backboard. The strips on the prototype were removed from a surplus alarm board. The screw terminals allow connections to be made with alligator clips, bare wire, and spade lugs. However, spring-loaded terminals, SIP sockets, or any other connector you might have on hand can be used here. Each point on the terminal strips is wired to a connection on the component, and labeled for identification.

The row of components above the terminal strips consists of four potentiometers (1-, 10-, and 100-kilohms and 1 megohm) and a 4- to 55-pF variable capacitor. To the right of that row is a DPDT toggle switch and six-position rotary switch. The binding posts on the extreme right output the 6- and 12-volts AC, previously mentioned.

On the left side are two analog meters (M1 and M2). Meter M1 is

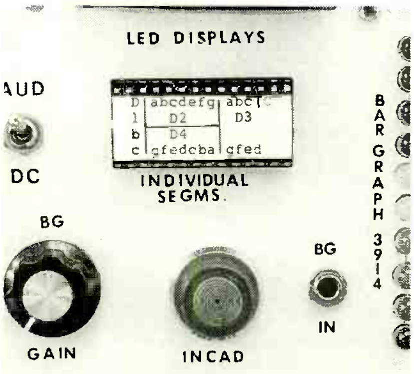


FIG. 5—A BARGRAPH is mounted in the center of the backboard.

PARTS LIST—MAIN UNIT

Resistors
1K panel-mount potentiometer
10K panel-mount potentiometer
100K panel-mount potentiometer
1 megohm panel-mount potentiometer
Capacitors
4 to 55 pF variable capacitor
Semiconductors
One 0.3-inch 7-segment display, common anode
Four 0.56-inch 7-segment displays, common anode
Four 0.56-inch 7-segment displays, common cathode
Power supplies
Texas Instrument surplus computer power supply, or equivalent
12.6-volt AC transformer
4-AA battery holder
9-volt battery connector
1.2 to 20 volt variable DC supply
120 VAC power strip
Other components
Two spring-loaded speaker-type terminals, six binding posts, 6-foot AC line-cord, plastic project cases, three 640-point breadboards, two 19-point terminal strips, heavy-duty DPDT toggle switch, momentary pushbutton switch, 6-position rotary switch, 0 to 1 mA analog meter movement, small push-on push-off switch, 11-pin SIP socket, 28-pin DIP socket, bayonet lamp socket with lens and bulb assortment, hookup wire and zip cord, hardware, seven panel knobs, TO-220 10-watt heatsink, 4-contact tie point.

PARTS LIST—BARGRAPH

IC1—LM3914 bargraph driver and 18-pin DIP socket, National Semiconductor
R1—1000 ohms, ¼-watt resistor
R2—5000 ohms, panel-mount potentiometer with switch
T1—audio transformer, 1K primary, 8-ohm secondary (Radio Shack 273-1380)
J1—⅛-inch phono jack and plug
D1—1N4001 diode
LED1–LED10—light-emitting diode, any color
S1—DPDT switch

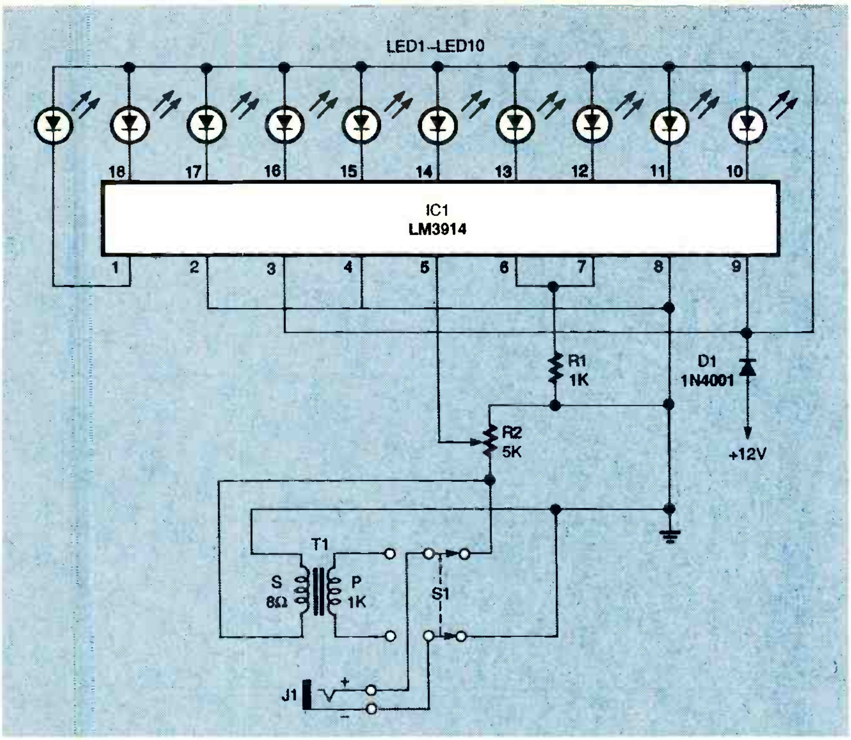


FIG. 6—LED BARGRAPH SCHEMATIC. The circuit consists mainly of an LM3914 bargraph display driver IC.

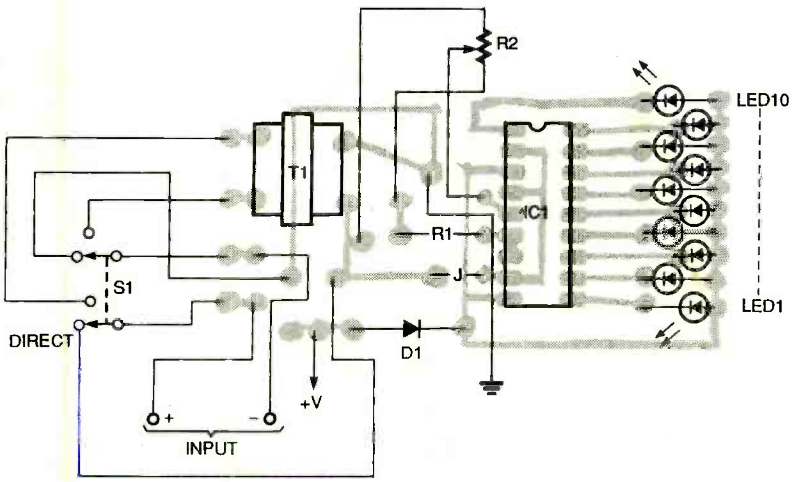


FIG. 7—PARTS-PLACEMENT DIAGRAM for the bargraph circuit.

rated for 0 to 1 milliampere, which is a useful value for many circuit designs, and M2 is 500 microampere, ± center scale unit. This is essential when designing a circuit where the output can swing either positive or negative. Meter M2 is illuminated, and the small push-button switch labeled L.O. activates the 6-volt lamp.

A bank of seven-segment LED displays is mounted in the top center of the backboard. The first row of four is in a multiplexed arrangement, with all like segments tied together. Connection to the multiplexed displays is accomplished via the SIP socket to the right, which is labeled accordingly. The second row of seven-segment displays is wired as a 3½-digit display that allows individual access to each of the 24 segments and the common anode. Connections to this display row are made via the DIP socket below it, which is marked appropriately for use with digital circuits having that type of output.

Below the DIP socket is an incandescent lamp indicator with a bayonet-type socket. Bulbs are easily changed, and they are available in 6-, 12-, 14-, and 28-volt versions.

The author installed a ten-step LED bargraph and a 3½-digit voltmeter on the backboard, both as a matter of personal preference. The bargraph is mounted in the center of the backboard as shown in Fig. 5. A schematic of the LED bargraph circuit is shown in Fig. 6. The circuit consists mainly of an LM3914 bargraph display driver IC. Switch S1 allows signals to be input to the driver chip

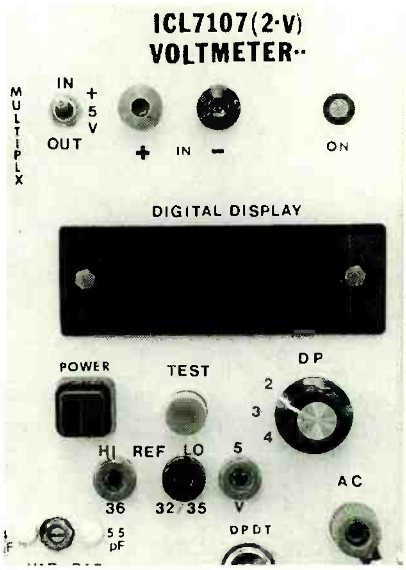


FIG. 8—A 3½-DIGIT VOLTMETER occupies the upper right hand corner of the backboard.

PARTS LIST—VOLTMETER

IC1—ICL7107CPL A/D converter/LED display driver, Harris
DISP1—two 2-digit common-anode 7-segment displays source
C1—0.22 µF, mica capacitor
C2—0.047 µF, mica capacitor
C3—0.01 µF, mica capacitor
C4—0.1 µF, mica capacitor
C1—100 pF, ceramic disc capacitor
R1—470,000 ohms, ¼-watt, 5% resistor
R2—1 megohm, ¼-watt, 5% resistor
R3—25,000 ohms, PC-mount potentiometer
R4—22,000 ohms, ¼-watt, 5% resistor
R5—100,000 ohms, ¼-watt, 5% resistor
S1—SPDT toggle switch
Miscellaneous: pushbutton switch, 3-position rotary switch, five banana jacks, green LED

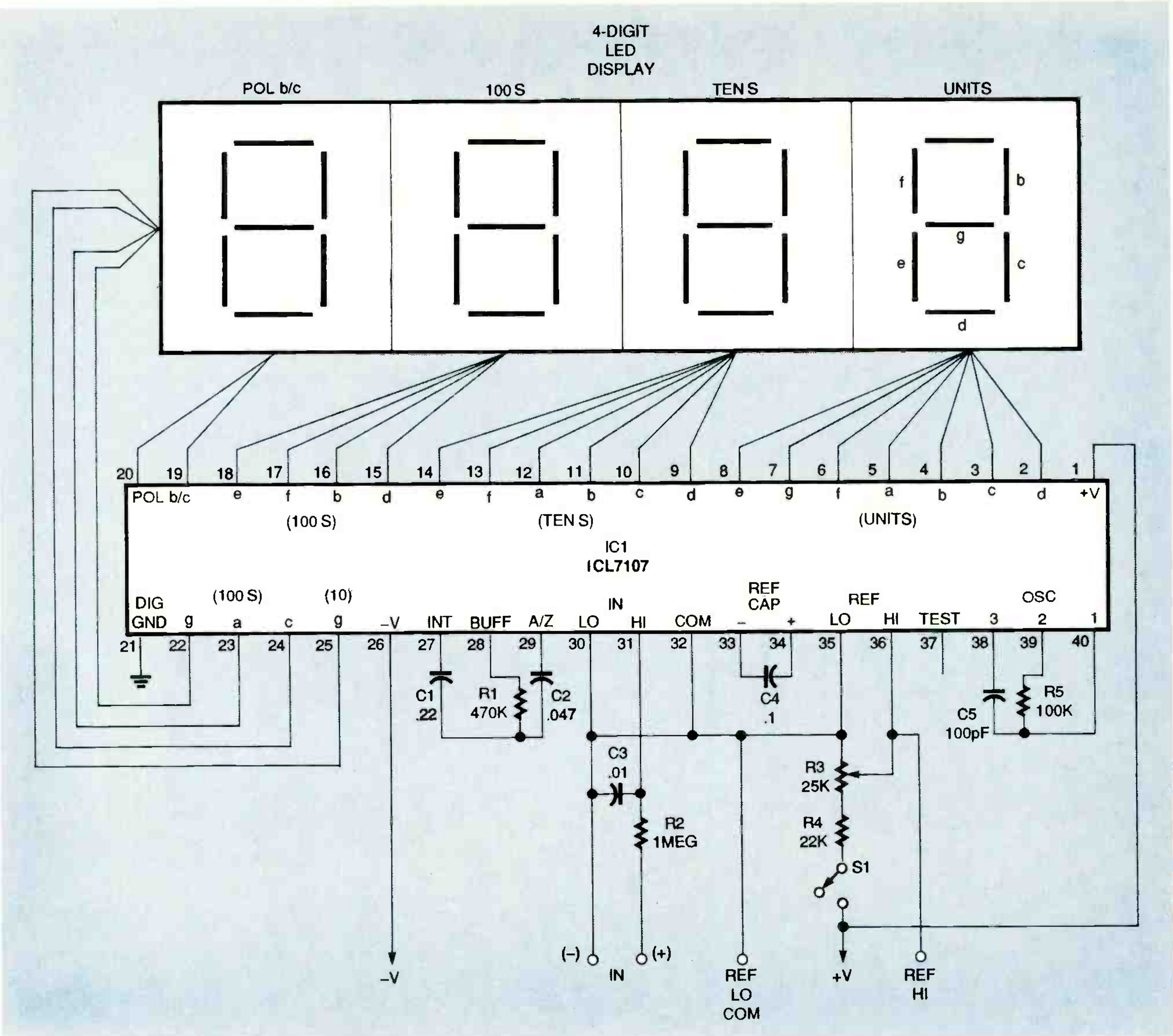


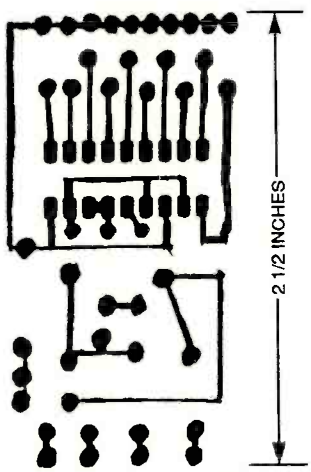
FIG. 9—THE SCHEMATIC DIAGRAM of the voltmeter circuit.

PARTS LIST—BCD DECODER

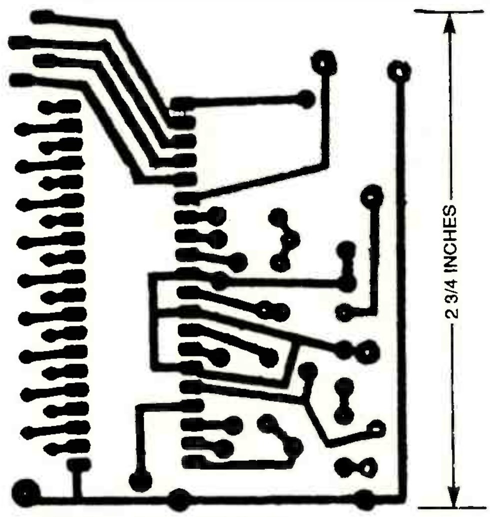
IC1—74LS48 BCD to 7-segment decoder
IC2—CD4553 3-digit BCD counter, Harris
Q1–Q3—2N3906 PNP transistors
R1–R7—220 ohms, ¼-watt, 5% resistor
R8–R10—1000 ohms, ¼-watt, 5% resistor
C1—0.001 µF, ceramic disc capacitor
DISP1—three common-cathode 7-segment displays

directly, or through a matching transformer T1 for audio.

Signals are input to the bargraph circuit at J1, a ⅛-inch mini phono jack. The 5-kilohm potentiometer (R2) controls gain. The author used a potentiometer with a built-in on/off switch so that power to the bargraph display could be turned on and off independently. You can either do the same, or use a separate switch for power.



BARGRAPH FOIL PATTERN.



VOLTMETER FOIL PATTERN.

Power for the bargraph circuit is provided by the TI computer supply.

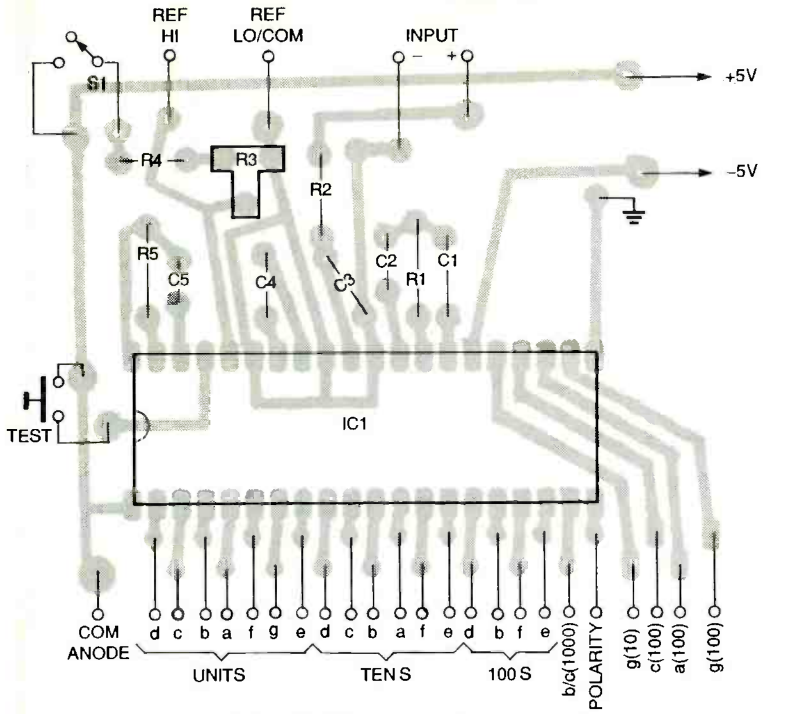


FIG. 10—PARTS-PLACEMENT DIAGRAM for the voltmeter circuit.

PARTS LIST AUDIO AMPLIFIER

IC1—LM386 audio amplifier, National Semiconductor
R1—10,000 ohms, panel-mount potentiometer with switch (or use separate potentiometer and switch)
C1—20 µF, 25 volts, electrolytic
8-position terminal strip
1½-inch, 8-ohm speaker

PARTS LIST—METER

M1—4- to 6-inch, 0 to 1 mA analog-meter movement
S1—8-position rotary switch
D1—1N4002 diode
R1—10 ohms, ¼-watt, 5% resistor
R2—100 ohms, ¼-watt, 5% resistor
R3—1000 ohms, ¼-watt, 5% resistor
R4—10,000 ohms, ¼-watt, 5% resistor
R5—100,000 ohms, ¼-watt, 5% resistor
R6—1 megohm, ¼-watt, 5% resistor
R6—10 megohms, ¼-watt, 5% resistor
Two banana jacks

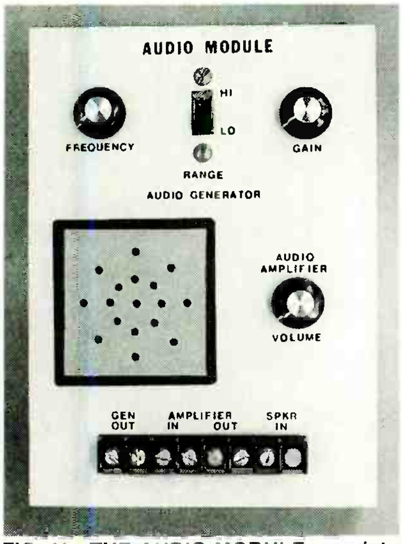


FIG. 11—THE AUDIO MODULE consists of an audio generator, an amplifier, a speaker, and a terminal strip.

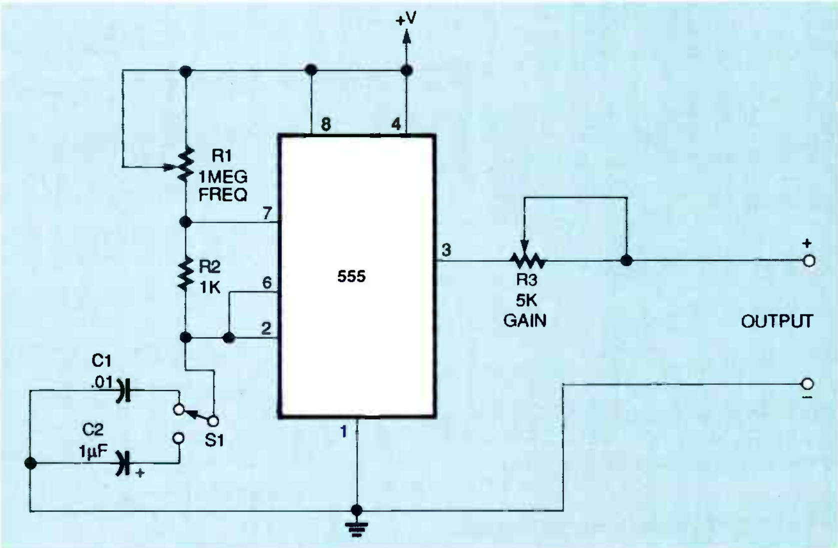


FIG. 12—SIGNAL GENERATOR. Potentiometer R1 sets the output frequency.

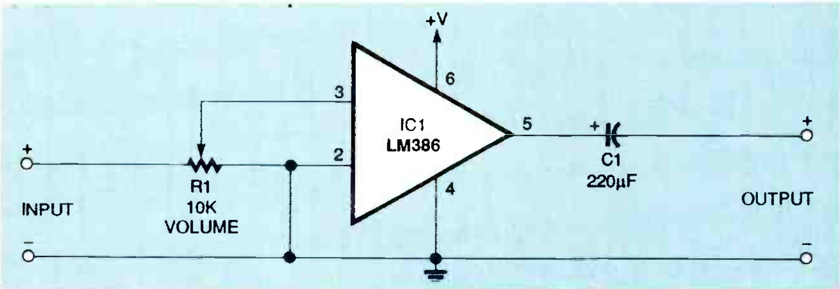


FIG. 13—AUDIO AMPLIFIER. This circuit has a gain of about 20.

A foil pattern is provided for the bargraph circuit, and the parts-placement diagram for it is shown in Fig. 7.

The 3½-digit voltmeter occupies the upper right hand corner of the backboard, as shown in Fig. 8. Figure 9 is the schematic diagram of the voltmeter circuit. A foil pattern is provided for this circuit, and Fig. 10 is its parts-placement diagram. This circuit can also be point-to-point wired. The circuit contains a Harris ICL 7107 analog-to-digital converter/ display driver. A standard 2-volt configuration was chosen for this circuit. Switch S1 allows the +5-volt source to be routed either to the on-board 25-kilo-

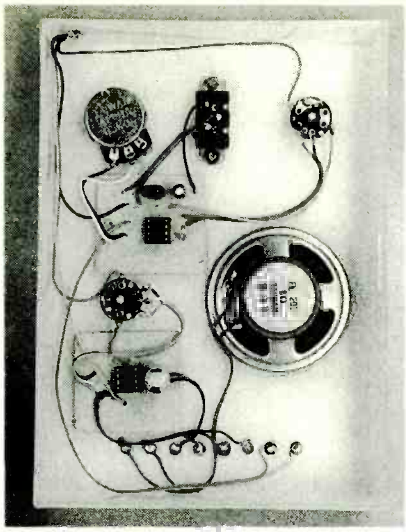


FIG. 14—THE AUDIO MODULE is too simple to call for a PC board, so point-to-point wiring was used.

FIG. 15—3-DIGIT BCD DECODER-driver is another practical function block.

PARTS LIST—AUDIO MODULE

IC1—L555 timer
R1—1 megohm, panel-mount potentiometer with switch
R2—1000 ohms,, ¼-watt, 5% resistor
R3—5000 ohms, panel-mount potentiometer
C1—0.01 µF, Tantalum
C2—1 µF, Tantalum
S1—SPDT switch

hm potentiometer, or to an external jack, depending on the need. To calibrate the meter, apply 1.2 volts from the variable power supply to the input, and adjust R3 until the display reads 1.200. Then, switch the input leads, and the display should read –1.200.

PARTS LIST—LOGIC PROBE

IC1—7404 hex inverter
R1—220 ohms, ¼-watt, 5% resistor
LED1—green light-emitting diode
LED2—red light-emitting diode
Two common-anode 7-segment displays (optional, see text) source

The left side of the base is reserved for add-on modules, which can have a number of different functions depending on what is needed. The audio module shown in Fig. 11 consists of an audio signal generator, an

Continued on page 78

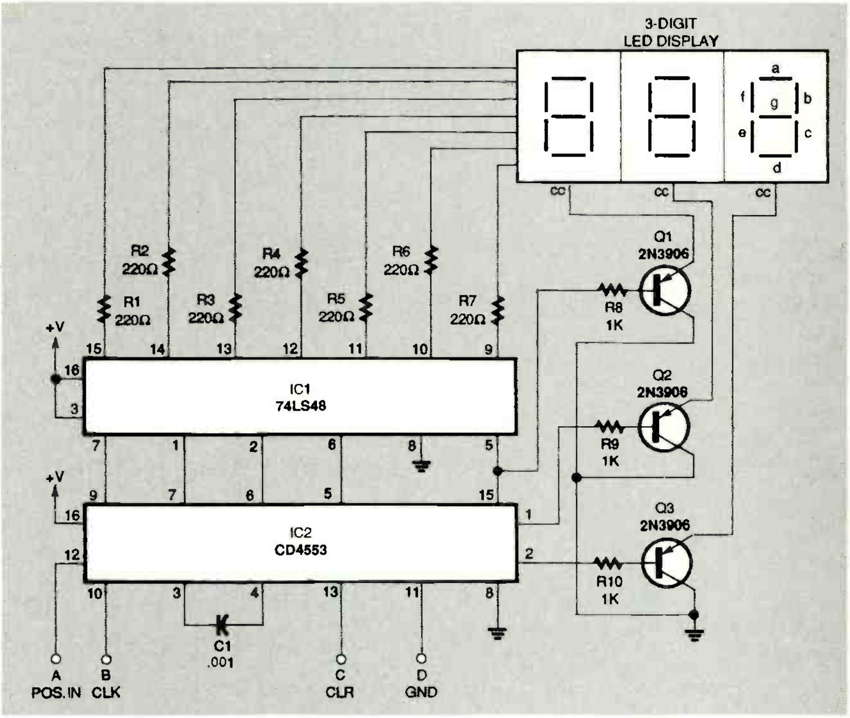


FIG. 16—THE BCD DECODER-DRIVER circuit will interface with any standard BCD output to produce a digital display.

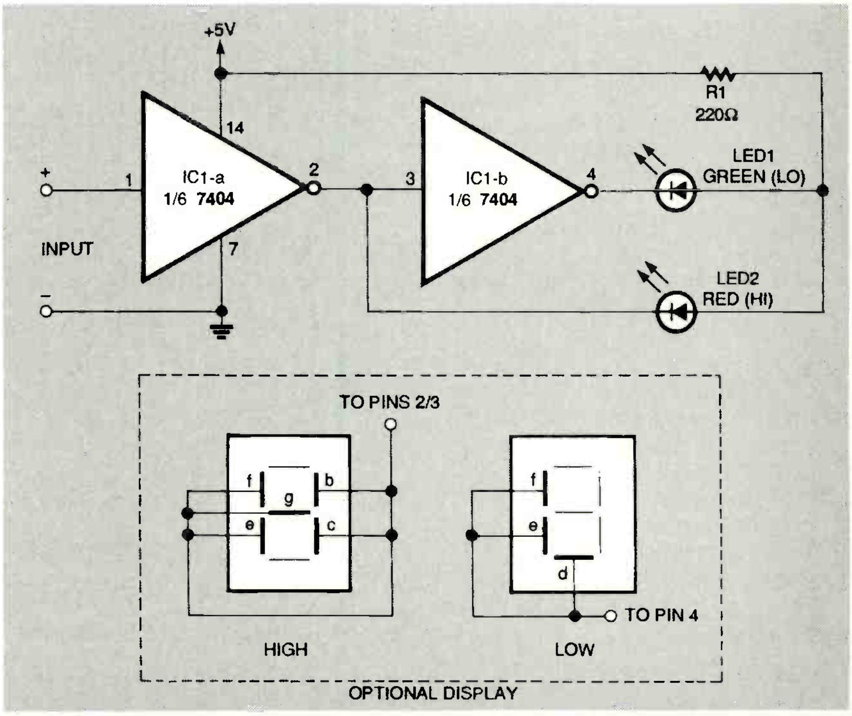
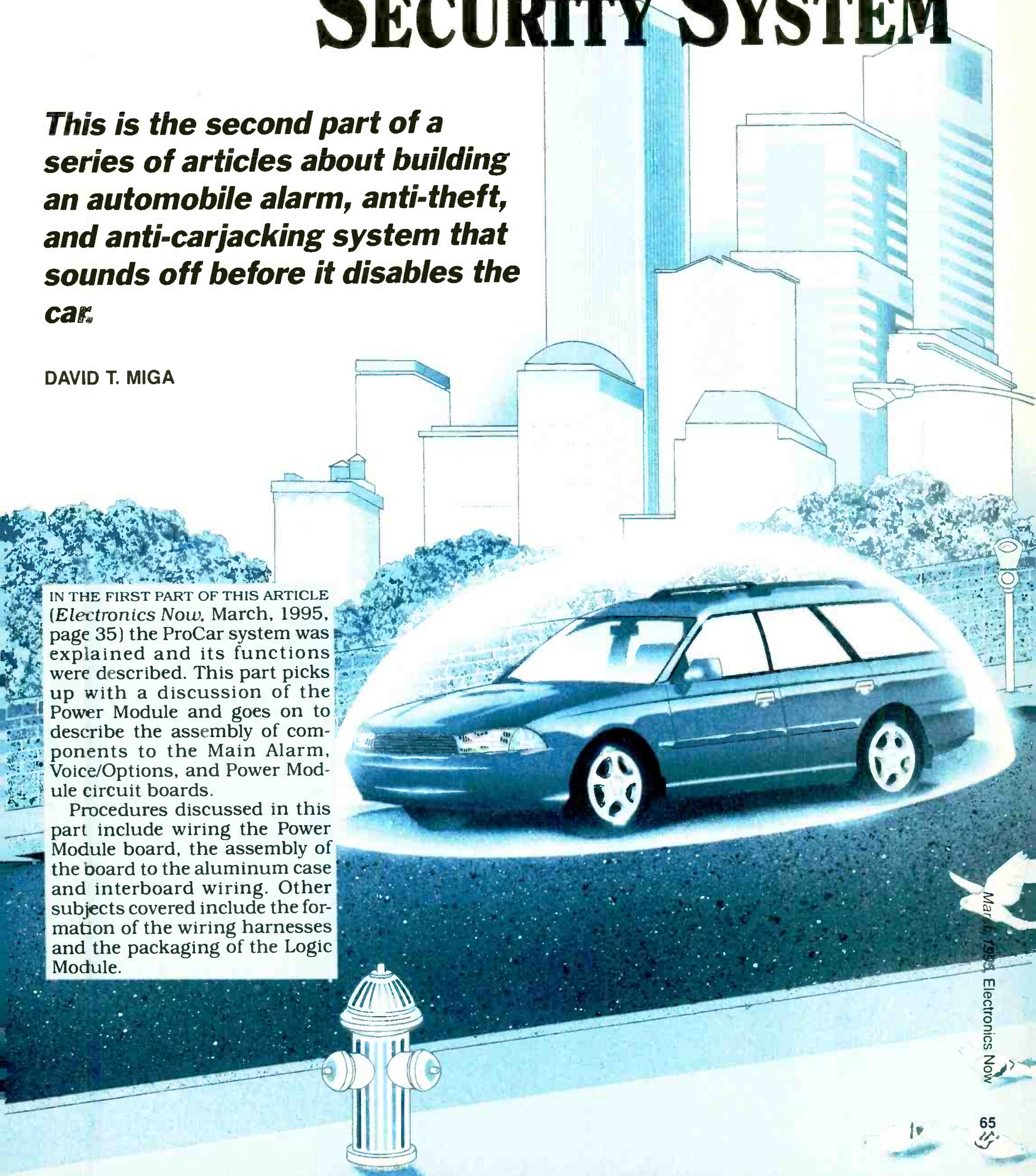


FIG. 17—A LOGIC PROBE is also included in BCD decoder module. The red LED lights to indicate a logic high, and the green LED lights to indicate a logic low.

The ProCar Security System

This is the second part of a series of articles about building an automobile alarm, anti-theft, and anti-carjacking system that sounds off before it disables the car.

DAVID T. MIGA



IN THE FIRST PART OF THIS ARTICLE (*Electronics Now*, March, 1995, page 35) the ProCar system was explained and its functions were described. This part picks up with a discussion of the Power Module and goes on to describe the assembly of components to the Main Alarm, Voice/Options, and Power Module circuit boards.

Procedures discussed in this part include wiring the Power Module board, the assembly of the board to the aluminum case and interboard wiring. Other subjects covered include the formation of the wiring harnesses and the packaging of the Logic Module.

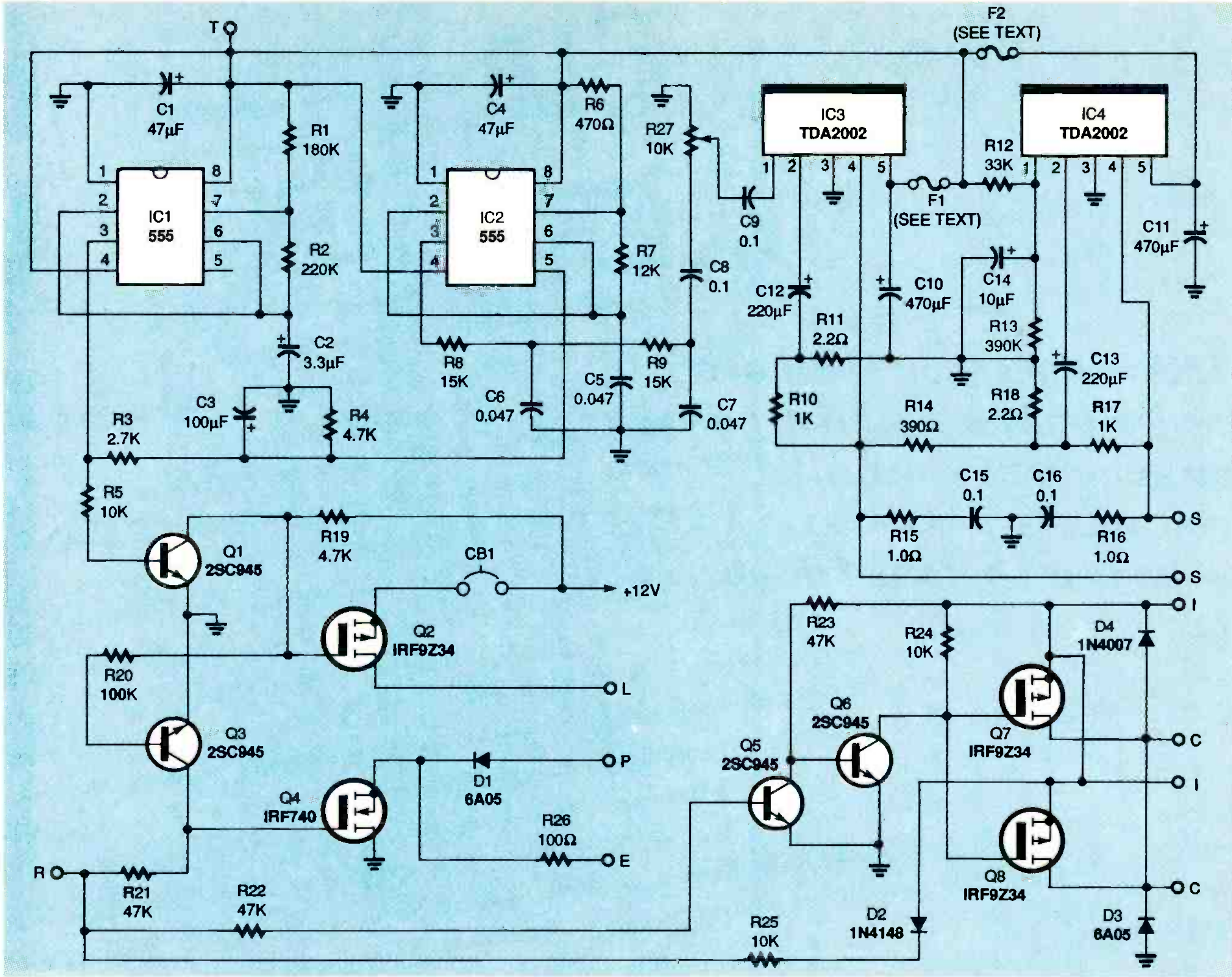


FIG. 4—SCHEMATIC FOR THE POWER MODULE. Off-board power ICs and MOSFETs power the alarm siren and other functions.

Power module

The Power Module is a small, aluminum, two-part case containing the single-sided Power Module circuit board. Figure 4 is the schematic for the Power Module circuit board, which includes the siren/amplifier circuit, the engine-stop circuits, and the light-flashing circuit.

Siren circuit

IC1 and IC2 are 555 timers configured as astable oscillators whose output can closely simulate a police siren. (If that kind of warning signal is illegal where you live, the omission of capacitor C3 will alter the output to the European police car and fire truck "he-haw" sound.

A filter consisting of 15-kilohm resistor R8 and 0.047µF capacitor C7 corrects the squarewave output, and TDA2002 power amplifiers IC3 and IC4, configured in a bridge, supply up to 16 watts of output.

Light-flashing circuit

Oscillator IC1, which oscillates at about 1 hertz, is part of the siren circuit. It also activates NPN transistor Q1 and P-channel depletion-mode MOSFET Q2 to provide up to 18 amperes of 12-volt power to flash the parking lights while the siren sounds. Transistor Q1 also triggers transistor Q3, which is part of the engine-cut-off circuitry.

When the lights flash and the siren sounds, the engine will temporarily stall and then restart. The driver will soon realize that there is engine trouble and stop the vehicle. This response occurs only when the *Armed line* is at logic high, as would occur in an attempted carjacking.

Engine disable

ProCar contains two completely unrelated engine disable circuits. The choice will depend on the builder's selection of interrupt. The simplest is the starter interrupt (the engine pulse circuit described in the previous paragraph), or a complete engine disable circuit that cuts off both fuel and ignition.

The complete engine disable circuit is recommended for automobiles with standard stick-shift transmissions because the engine will still be turning as long as the car is coasting, thus retaining both steering and braking power.

However, the engine pulse and starter interrupt circuit should be selected for automobiles with automatic transmissions. Completely disabling the engine of an automobile with an automatic transmission and power brakes and steering will make steering and braking difficult. That part of the circuit including N-channel MOSFET Q4 will apply ground to lines "P" or "E" that are synchronized to the siren and light flasher.

If the car has a carburetor and a single ignition coil, the "P" line is connected to the ignition points or negative coil, causing the engine to alternately stall and restart in short cycles when the siren and lights are activated. The coil will not be damaged because MOSFET Q4 has a high output impedance which is enhanced by diode D1 so that the voltage drop across the coil is only 7 volts, rather than 12 volts.

The "E" output, called the Engine Sensor Defeat (ESD) line, should be selected for newer automobiles with engine microcontrollers, fuel injection, or multiple-coil systems. The ESD (E) line is grounded through 100-ohm protective resistor R26.

The E wire can be connected to the throttle position sensor or mass air sensor output to upset the microcontroller, which will not be damaged because of the presence of resistor R26. The engine will not stall, but because of the incorrect signals, the engine controller will make the engine perform erratically. (Some fault codes are stored in the computer's memory.) This will cause the CHECK ENGINE indicator to turn on.

The alternative engine circuit performs in a way that is the exact opposite the "P-E" output from Q4. Where that circuit grounds the "P" and "E" lines, the interrupt circuitry that includes P-channel depletion mode MOSFETs Q7 and Q8 interrupts power between the "I" and "C" lines. This circuit can power the fuel injectors or be wired as a simple starter-interrupt function.

When ProCar is activated, the Armed line is high, saturating NPN transistor Q5 connected to NPN transistor Q6. As a result, the pair will not conduct. The pair of P-channel depletion-mode MOSFETs, Q7 and Q8,

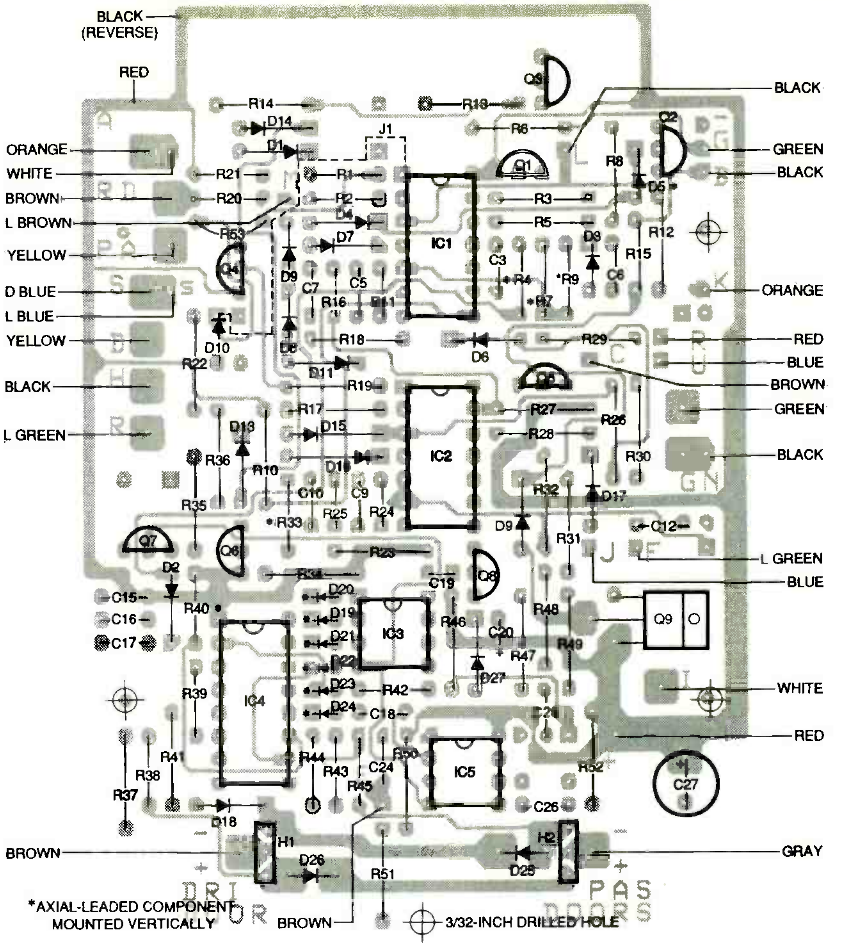
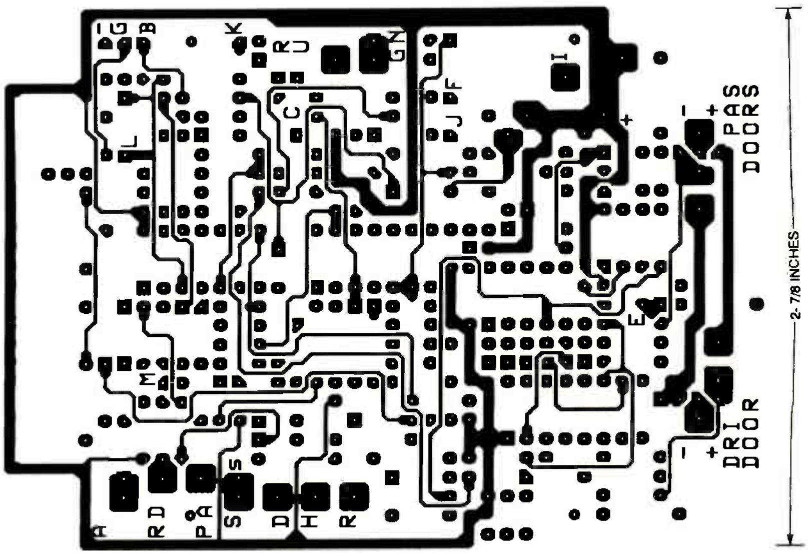


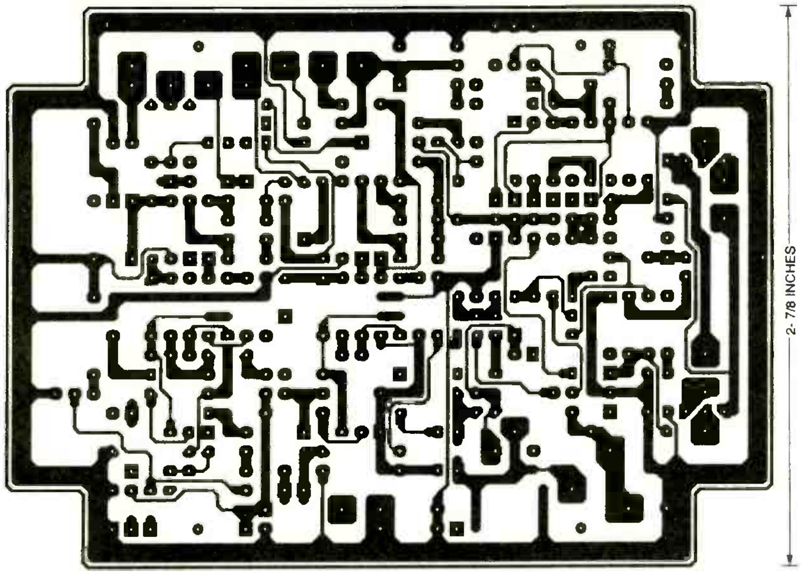
FIG. 5—MAIN ALARM BOARD PARTS PLACEMENT DIAGRAM. All components but 10 capacitors are on this side of the board. All inter-board wiring starts here.



MAIN ALARM BOARD FOIL PATTERN (principal component side)

provide backup or failsafe so that the owner/authorized driver will never be stranded.

Moreover, each MOSFET is rated for 18 amperes so there will be adequate built-in capacity for powering high-current circuits such as fuel injectors or fuel pumps. Diode D3 protects MOSFETs Q7 and Q8 from inductive spikes originating at the starter relay, and diode D4



MAIN ALARM BOARD FOIL PATTERN (10 capacitor side)

PARTS LIST

Power module
All fixed resistors are ¼-watt, 10%.
R1—180.000 ohms
R2—220,000 ohms
R3—2,700 ohms
R4, R19—4,700 ohms
R5, R24, R25—10,000 ohms
R6—470 ohms R7—12,000 ohms
R8, R9—15,000 ohms
R10, R17—1,000 ohms
R11, R18—-2.2 ohms
R12—33,000 ohms
R13—390,000ohms
R14—390 ohms
R15, R16—1 ohm
R20—100,000
R21, R22, R23—47,000 ohms
R26—-100 ohms
R27—10,000 ohms, trimmer potentiometer, PCB mount
Capacitors
C1, C4—47μF, 16 C2—3.3μF, 50 volts, aluminum electrolytic
C3—100μF, 16 volts, aluminum electrolytic
C5, C6, C7—0.047μF, 50 volts, polyester
C8, C9, C15, C16—0.1μF, 50 volts, polyester
C10, C11—470μF, 16 volts, aluminum electrolytic
C12, C13—-220μF 16 volts, aluminum electrolytic
C14—10μF 25 volts, aluminum electrolytic
Semiconductors
D1, D3—6A05 silicon diode, 6 ampere, 50 volts, Diodes Inc. or equiv.
D2—1N4148 silicon diode
D4—1N4007 silicon diode
IC1, IC2—555 timer
IC3, IC34—TDA2002 power amplifier, 10 watt, National Semiconductor or equiv.
Q1, Q3, Q5, Q6—2SC945 NP transistor, NEC or equiv.
Q2, Q7, Q8—IRF9Z34 PN-channel, depletion mode MOSFET International Rectifier or equiv.
Q4—IRF740—PN-channel, depletion mode MOSFET International Rectifier or equiv.
Other components
LED1—light-emitting diode, dual color, green/blinking red T1¾ Toshiba No. 111DC or equiv. PL1—15-pin plug, nylon shell, AMP A1462 with A1440 male contacts or eqiv. SO1—15-pin jack, nylon shell AMP A1463 with A1441 female contacts or equiv.
Miscellaneous: main alarm circuit board; voice/options circuit board; power module circuit board; two-part logic module case (LMB Heeger No. 402, 4.0 L×3.0 W ×1.25 H inches, inside), plastic; two-part power module case (LMB Heeger No. J875 4.0 L×2.25 W×2.25 H inches, aluminum; three-wire cable (red, black, and green), type CM, Carol or equiv., five feet; lengths of stranded insulated hookup wire in a range of colors suitable for the automotive environment; rectangular T)-220 mica insulators (2); miscellaneous nuts and bolts; rubber grommet, 0.5-inch ID; solder.

protects the MOSFETs if the system installer should accidentally interchange the input and output wires.

The possibility that the car thief might know enough about the protective system to cut the three wires between the Logic module and the power module was considered in the design. The *Armed line* must be at logic high to stop the engine, and sufficient voltage through diode D2 will keep the engine cut off. During normal operation, the *Armed line* is grounded by the NPN transistor Q7 in the Main Alarm board (shown in Fig. 1 last month).

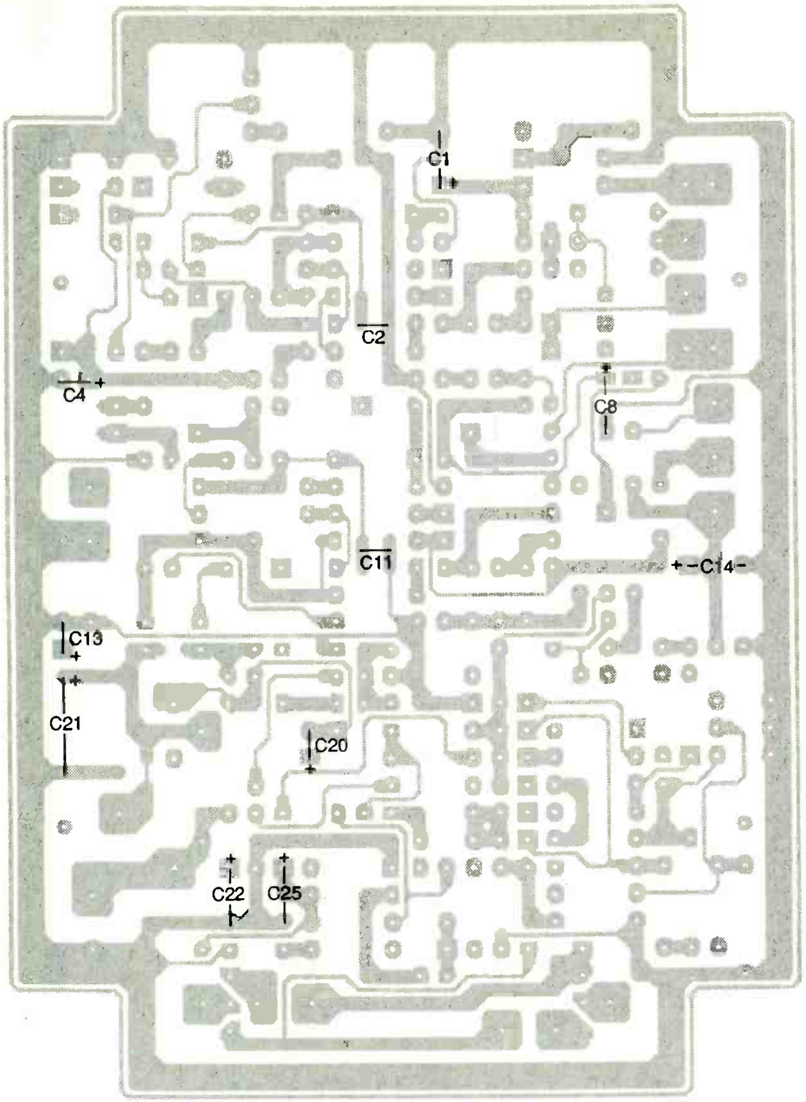
ProCar circuit boards

If you prefer to make your own circuit boards, the foil patterns of all three boards are included here. The two double-sided boards with plated-through holes (Main Alarm and Voice/Options) have clear-drilled mounting holes, and the single-sided Power Module board has clear-drilled mounting holes. However, completed boards can be purchased from the source given in the Parts List.

Follow standard leaded-component insertion and soldering practice in constructing the electronic circuits. Before inserting components with polarities (diode cathodes and positive terminals of electrolytic capacitors), verify that they are correctly oriented as shown in the five parts placement diagrams. Position all integrated circuits in DIP cases so that the notches or dots indicating the position of pin 1 are as shown on the three parts placement diagrams where they are shown.

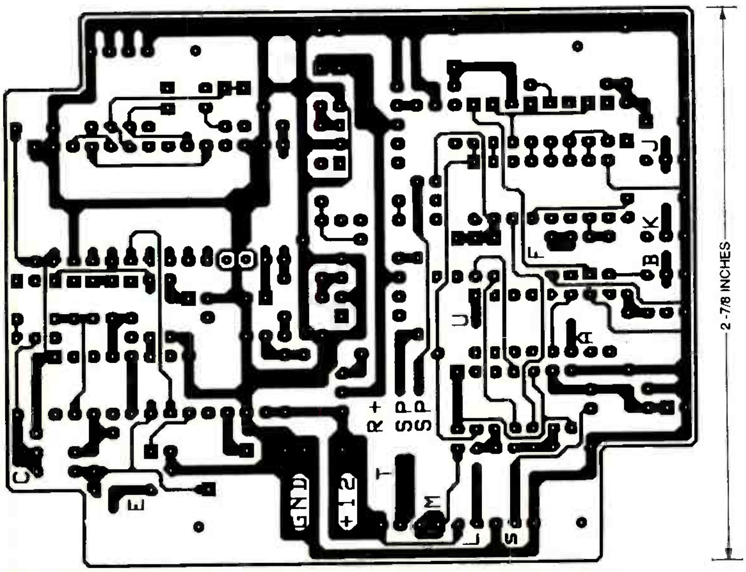
Logic module

The Main Alarm and Voice/Options boards will both be mounted in a two-part "clamshell" plastic case made as two matching covers. The Main Alarm board will be mounted sandwich-like in one cover and the Voice/Options board will be mounted in the opposing cover in later steps. The inter-board connections and external harness wiring will also be performed in later steps.



NOTE: ALL RADIAL-LEADED CAPACITOR LEADS ARE BENT 90°
SO BODIES LIE FLAT AGAINST BOARD

FIG. 6—MAIN ALARM BOARD PARTS PLACEMENT DIAGRAM, reverse side. Leads of 10 radial-leaded capacitors are bent so capacitors lie flat against the board.



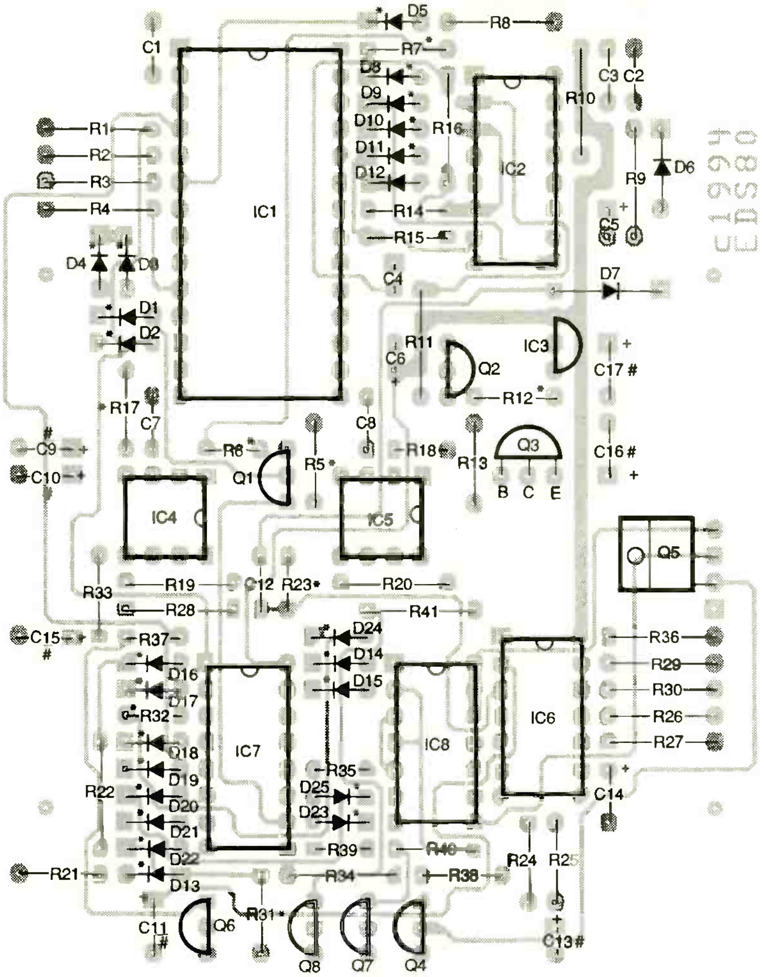
VOICE/OPTIONS BOARD FOIL PATTERN (principal component side)

Main Alarm board

Refer to the parts placement diagram for the component side of the Main Alarm board, Fig. 5. Start by inserting all of the diodes, resistors, transistors and non-electrolytic capacitors on the top side of the board.

NOTE: The axial-leaded resistors and diodes that are to be mounted vertically are indicated with an asterisk in Fig. 5. Carefully bend one lead back about 180° with respect to the second lead of each of the designated resistors and diodes so that they can be inserted in the closely spaced circuit board holes shown on Fig. 5.

Then insert all of the DIP-packaged ICs and radial-leaded electrolytic capacitors. Solder all of these components in position. Place an insulating sleeve over jumper J1 and solder it in position. Do not trim any excess lead lengths at this time.

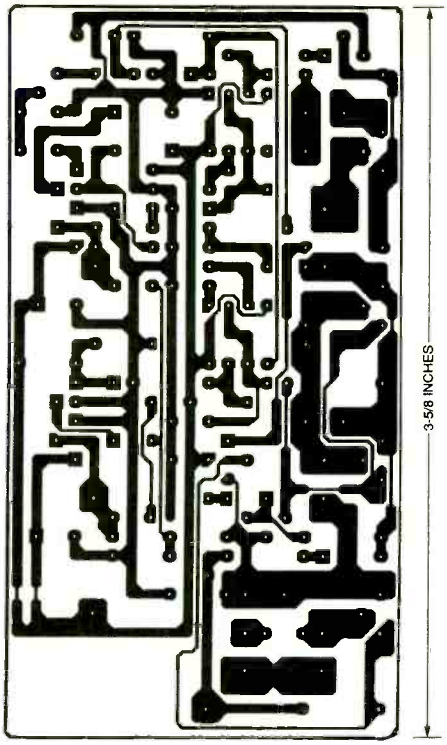


CLEAR DRILLED HOLE: 3/32 INCH

* AXIAL-LEADED PART MOUNTED VERTICALLY

RADIAL-LEADED PART, LEADS BENT 90° TO LIE FLAT AGAINST BOARD

FIG. 7—VOICE/OPTIONS PARTS PLACEMENT DIAGRAM. The voice record/playback IC1 provides 16 seconds of voice messages.



FOIL PATTERN FOR THE POWER MODULE.

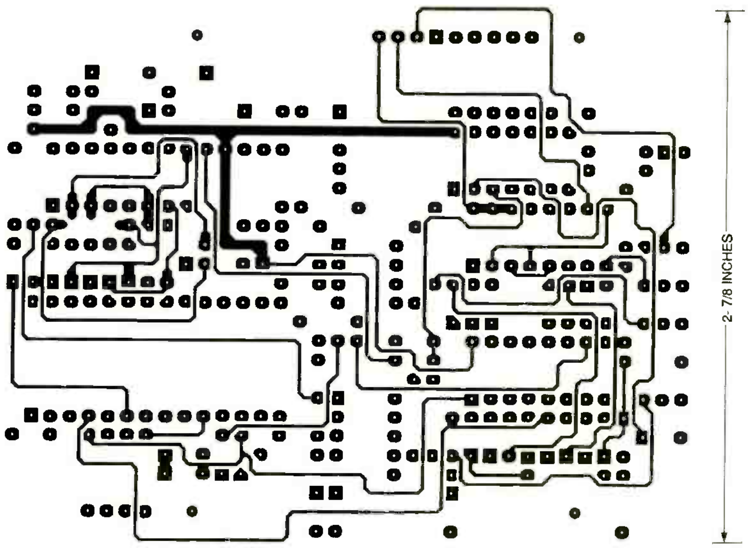
NOTE: Omit all external and inter-board wiring at this time. This wiring will be done after completing the component insertion and soldering on all three boards.

Refer to the parts placement diagram Fig. 6. Mount the eight capacitors on the reverse side: C1, C2, C4, C8, C11, C13, C14, C20, C22 and C25. Capacitors C2 and C11 are 0.1µF monolithic ceramic capacitors that are soldered between IC1 and IC2 in the pads under those ICs. Form right-angle bends in the leads of all capacitors (indicated by the pound sign in Fig. 6) so that they can be positioned flat against the board and take up less space.

After soldering all leads, verify that all solder joints are clean and shiny. Resolder any cold solder joints, indicated by their gray, irregular surfaces. Verify that there are no inadvertent solder bridges. Recheck the orientation of all diode and capacitor polarities.

Voice/options board

Insert all components of the Voice/Options board on the component side of the board, as shown in Fig. 7, as close as pos-



 VOICE/OPTIONS BOARD FOIL PATTERN (interconnect wiring side)

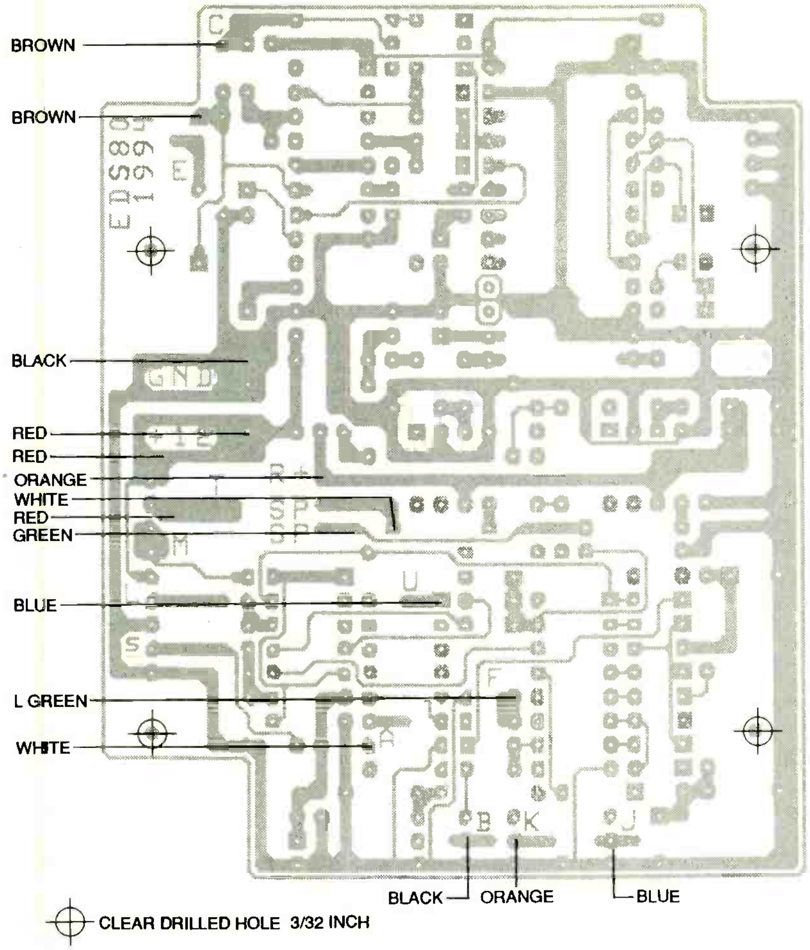


FIG. 8—VOICE/OPTIONS PARTS PLACEMENT DIAGRAM reverse side. Wiring for the main alarm board is located here.

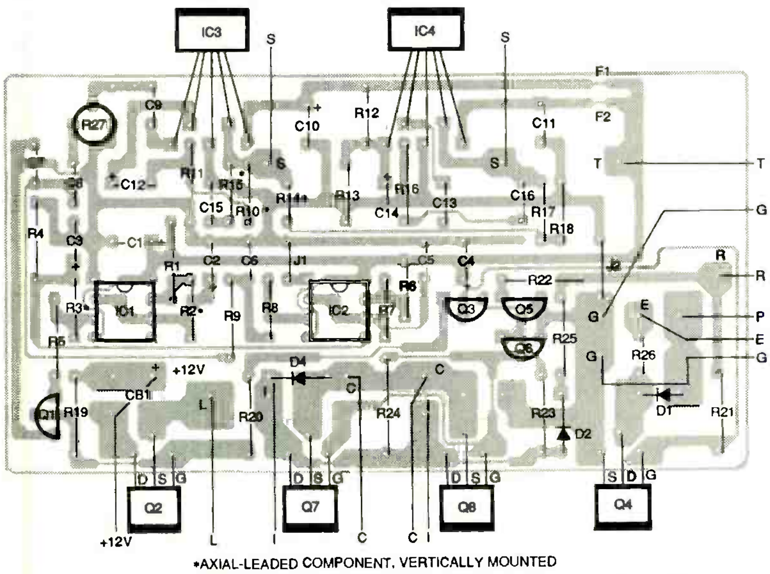


FIG. 9—POWER MODULE PARTS PLACEMENT DIAGRAM. Power transistors and ICs are mounted on sidewalls of aluminum case for heat sinking.

sible to the board. (The space available inside the covers of the case is limited.) Solder all components, but do not trim excess lead lengths.

Figure 8 shows the locations of the connecting wires on the reverse side of the Voice/Options board to be inserted and soldered later.

Power Module board

Refer to the Power Module parts placement diagram Fig. 9. NOTE: The schematic for the power module board shows two fuses, F1 between terminal "T" and C10 and F2 between terminal "T" and C11. The effective resistance of the narrow copper traces on the board will function as fuses so that no discrete fuses are required.

Start assembly by bending and inserting the two jumper wires, J1 and J2. Then insert all of the small resistors and capacitors (including those whose leads are to be bent for vertical mounting, as indicated by the asterisks on Fig. 9). Position these components close to the board, and solder them in position. Do not trim excess component lead lengths at this time. Insert and solder the small-signal transistors paying attention to polarity.

insert the DIP-packaged integrated circuits IC1 and IC2, observing the correct orientation of pins. Then insert the radial-leaded capacitors observing their polarities. Solder all the leads of these components.

Bend the leads of integrated circuits IC3 and IC4, and four power transistors, Q2, Q4, Q7 and Q8, so that they stand vertically at the edges of the circuit board with the heatsink tabs facing outward. Solder them in position, and trim all excess lead lengths at this time. Verify that there are no inadvertant solder bridges and cold solder joints. Correct all soldering errors found before proceeding any further.

The Power Module circuit board is to be mounted in an aluminum channel, one of two-parts of an aluminum case, in later steps. It will be necessary to insert the circuit board in the aluminum channel and mark the locations of holes in the power semiconductor heatsink tabs on the sidewalls of the case for drilling and fastening with nuts, and bolts. This procedure as well as all wiring between circuit boards and the formation of external wire harnersses will be described in the next few paragraphs.

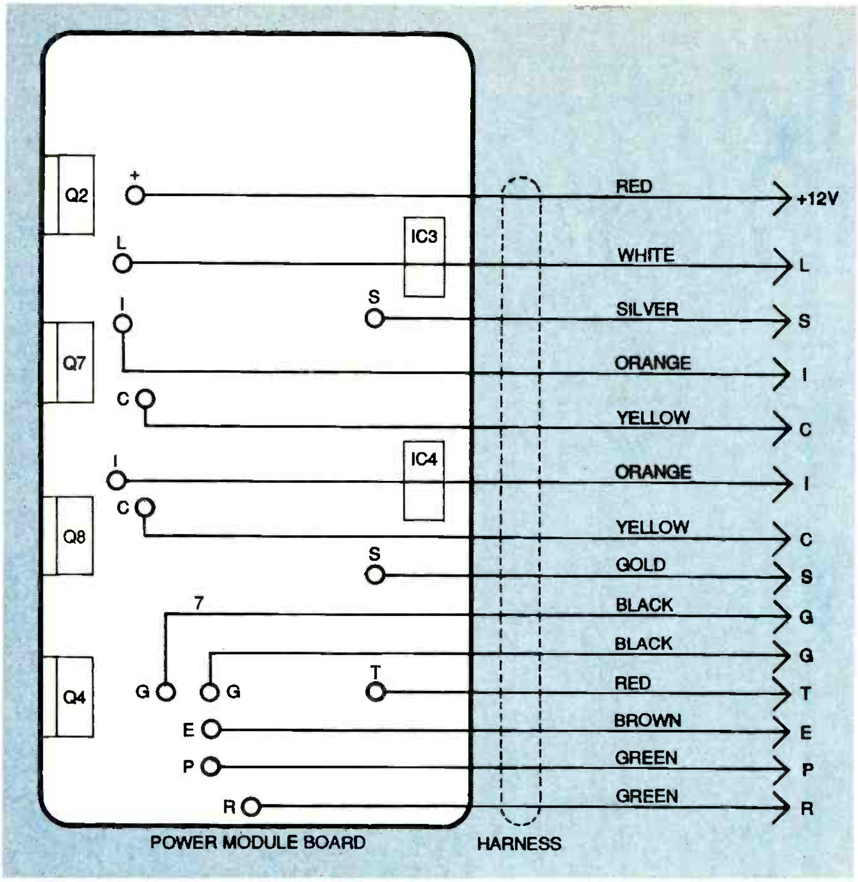


FIG. 10—POWER-MODULE WIRING HARNESS. Color-coded hookup wires are soldered to the circuit board, as shown.

Power Module wiring

Refer to Fig. 10 for the wiring of the Power Module board to form the external wiring harness. Cut lengths of No. 18 AWG insulated, stranded, tinned hookup wire in the colors shown to 8-inch lengths. Follow the color coding shown in Fig. 10 and strip both ends of the wire. Solder one end of each wire to the pad locations on the board designated by letters. Verify that all wiring is correct, and make any corrections necessary. Then trim all excess component lead and wire lengths.

NOTE: In a later step, the wires will be bundled to form a harness that will be passed through a grommet in the sidewall of the aluminum case opposite the location of Q4.

Power Module packaging

Refer to the exploded view of the Power Module in Fig. 11. Position the circuit board in the channel half of the aluminum case so that there is a clearance distance of about 1/16-inch between the solder side of the board and the bottom of the channel. Verify that the centers of the holes in the TO-220 packaged power semiconductors are about 7/8-inch above the bottom of the channel.

Mark and centerpunch the locations of the six 1/8-inch holes to match those in the heatsink tabs of power transistors Q2, Q7, Q8 and Q4 on one sidewall and IC3 and IC4 on the the opposite sidewall. Mark and centerpunch the location of the 11/16-inch grommet hole as shown in Fig. 11. Drill or form all holes and insert the 5/8-inch rubber grommet in the large hole.

Position the circuit board in the case channel, as shown in Fig. 11. Align the drilled holes in the case with the punched holes in the heatsink tabs. Slight misalignment of the holes in the case and power MOSFET heatsink tabs can be corrected by carefully bending the leads of the power semiconductors.

Place rectangular mica transistors under the heatsink tabs of power MOSFET transistors Q2, Q7, Q8, and Q4 and fasten them to the case sidewalls with 1/4-inch long screws and nuts, as shown in Fig. 11. Then fasten power amplifiers IC3 and IC4 to the case sidewalls with 1/4-inch long screws and nuts, as shown in Fig. 11. NOTE: the power amplifiers, IC3 and IC4, are grounded, so they need not be insulated.

Carefully gather the 14 soldered wires together and form them into a bundle and pass it through the grommet in the sidewall. The bundle can be cabled with wire ties or a length of heat-shrinkable tubing to form a jacket. Terminate the bundle with the 15-position connector socket SO1.

Module Interconnection

Refer to Fig. 12, the interboard wiring diagram. Place the two circuit boards together in the orientation shown in Fig. 12 with a separation of about 1 inch. The color-coded interconnecting wires connect (reading from left to right and down) points A, L, B, M, S, K, C, U, GND, J, F, +12V, and E.

Cut color-coded No. 28 AWG stranded, tinned, hookup wire to lengths so that, when soldered in position, they will connect the labeled circuit board pads. The 1-inch separation distance provides enough slack to permit the boards to be opened out for testing and maintenance. NOTE: Excessive wire lengths or heavier wire will make it difficult close the case halves when the interconnected boards are fastened into the plastic case. Strip both ends of the wires and solder one end of each in position.

External module wiring

Refer to Fig. 13, the external wiring diagram. The wires that form the external harness are terminated in the Main Alarm board pads designated (reading counterclockwise) A, RD, PA, S, D, H, R, +DRI DOOR, +PAS DOOR, I, R G, and "–". On the Voice/Options board, these wires are designated (reading left to right) GND, T, +12V, SP, SP, and R+.

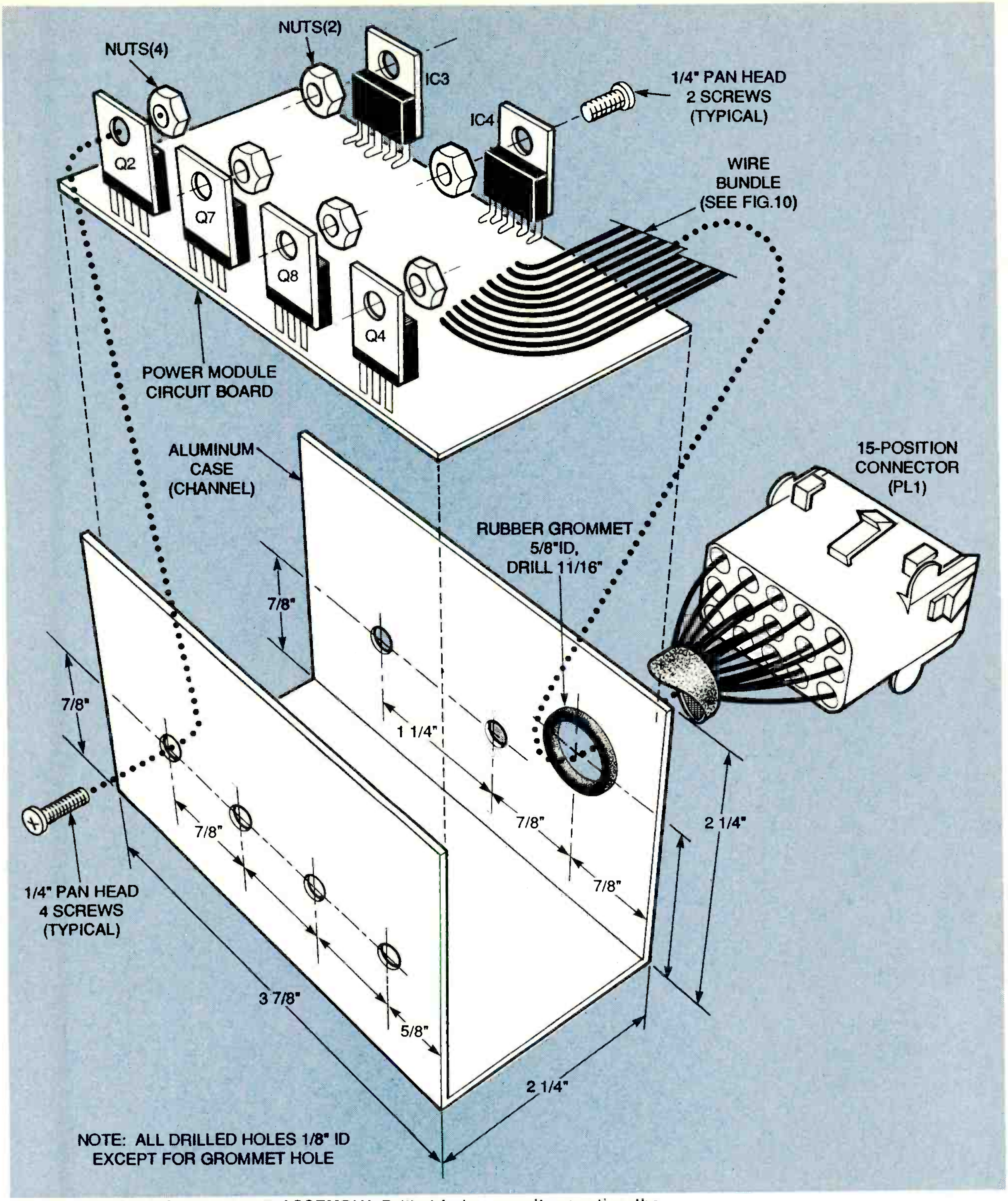


FIG. 11—POWER MODULE/CASE ASSEMBLY. Drilled holes permit mounting the power semiconductor heatsink tabs to the case sidewalls. The grommet protects the bundled wires.

The black, green, and red wires that connect to pads "–," G, and R, respectively, on the Main Alarm board are part of a three-wire cable to LED1. Cut this cable to a length of at least 3 feet. Cut another 10-inch length of the same type of three-wire cable for the connection to the Power Module. The black and green wires terminate of the Main Alarm board, and the red wire on the T pad of the Voice/Options board.

The black, brown, yellow, and red wires (upper left side of the Main Alarm board) will connect it to the Remote RF Receiver. If you intend to include this unit, cut 12-inch lengths in those colors from No. 28 AWG, stranded, tinned hookup wire. Strip both ends of the wires.

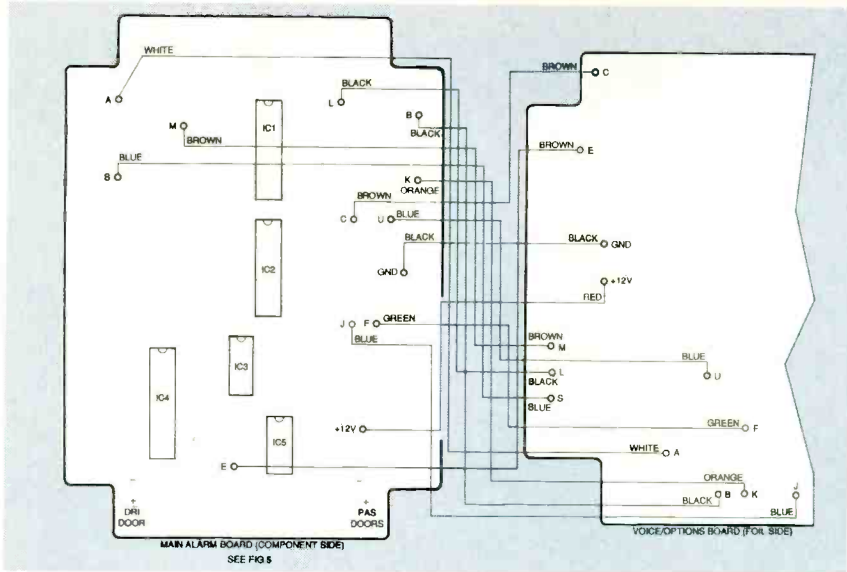
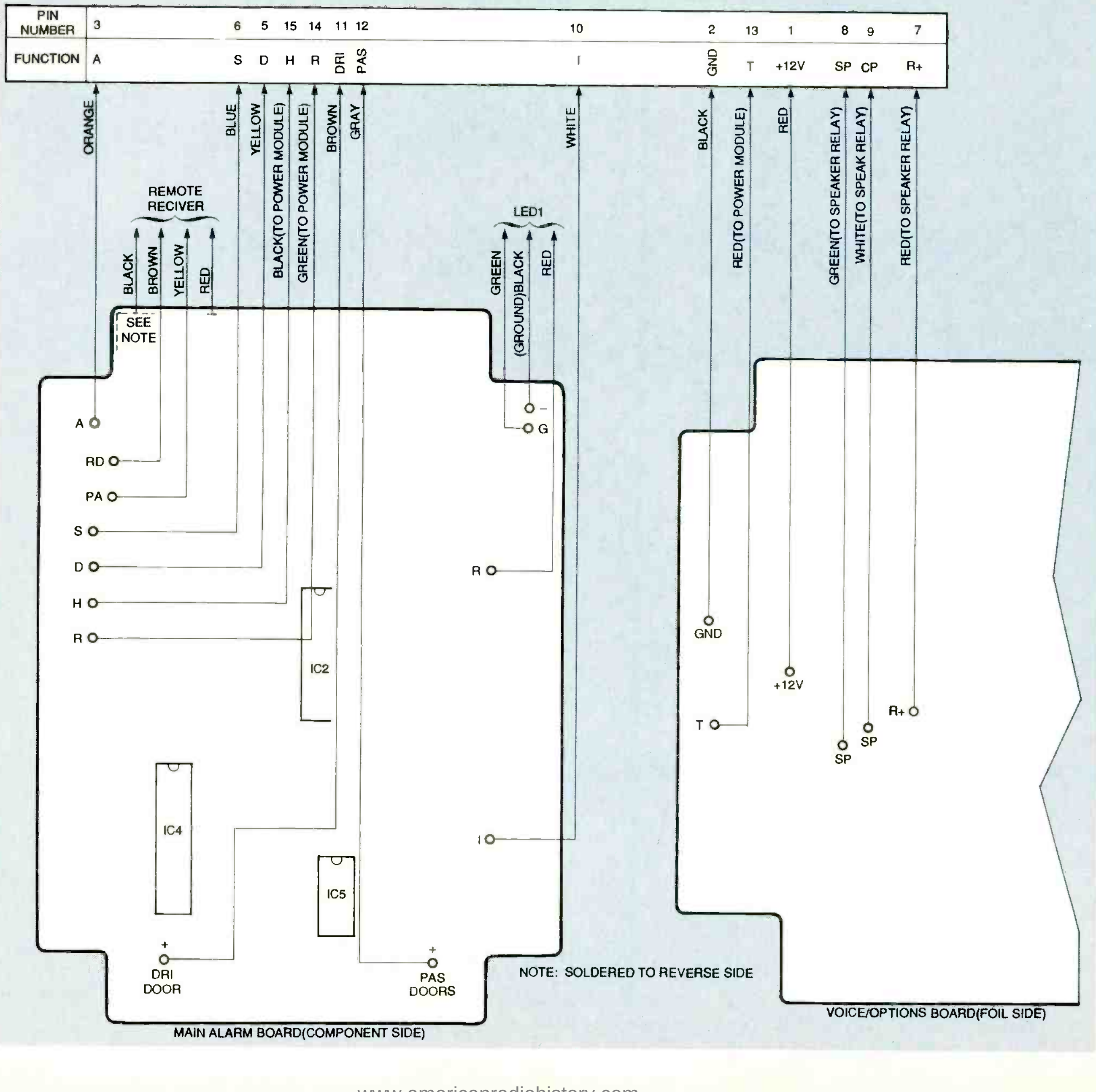


FIG. 12—INTERBOARD WIRING BETWEEN THE MAIN ALARM AND VOICE/OPTIONS boards. Slack in the wires permit the boards to be separated for service.

FIG. 13—LOGIC MODULE WIRING HARNESS. Color-coded wires from the Main Alarm and Voice/Options boards form the harness that terminates in connector socket SO1.



HARDWARE HACKER

Low-cost TV data displays, thoughts on brain implants, digital sinewave generators, a stunning new radio receiver, and distortion reduction schemes.

DON LANCASTER

I am going to start off by recalling my articles on the subject of television data display. Articles on Hacker TV data displays first appeared in the September 1973 issue *Radio-Electronics* with my *TV Typewriter*. This was followed by *Put the Time on Your TV Screen* in the September 1974 issue starting on page 33. These soon led to the *TV Typewriter Cookbook*, that *Cheap Video Cookbook*, and *Son of Cheap Video*. Sadly, these are long out of print, but I hope to reissue them on CD-ROM someday.

The the fastest, cheapest, and simplest way to put data on a TV screen is with a Commodore C-64 that you should be able to get for about $30 from a yard or flea market sale. If you want to superimpose data over existing video, the obvious choice is with a *Video Toaster* from *NewTek*, a company that, incidentally, offers some dandy free demo videos.

But *Philips* (formerly Signetics) makes the SAA5252 line 21 acquisition and display IC that sells for about $8. It can superimpose a full screen of first quality data over existing video program material. The circuit shown in Fig. 1 is simple and can be built easily. Unfortunately, advanced hardware, interface and programming skills are required to perform the initial design and debug steps.

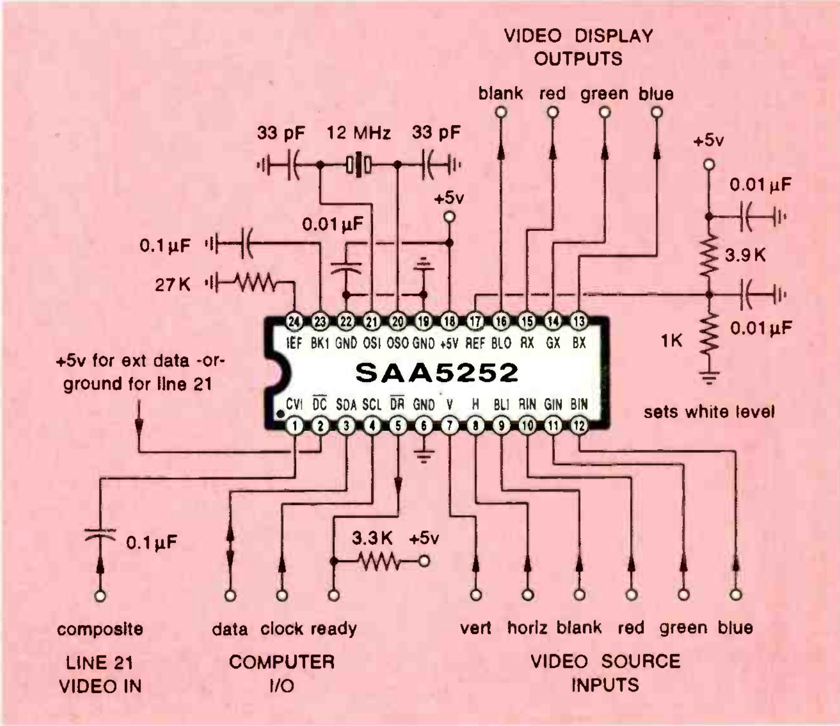


FIG. 1—THIS $8 TV DATA DISPLAY doubles as a line 21 decoder. The final circuit is simple, but interface and programming skills are required to build and run it.

For display of custom messages or data, an additional computer source or a companion microcontroller is needed. A PIC microcontroller is ideal for this.

The SAA5252 has several modes: It intercepts existing red, green, and blue video input lines. Then, at your bidding it can do nothing, overlay data, superimpose standard line 21 information, or enhance the line 21 information. Examples include shadowed or rounded characters and several unique display modes.

Line 21 services often include hearing impaired or foreign language subtitles. Both fields are selectable when offered. The line 21 information need *not* come from the same source as your final display.

Full genlocking is included. This is done by pre-storing the data. There are 80 characters in its set. Note that "zero" and "oh" share the same $4F character code. Separate control commands give you seven colors, optional flashing, italics, or an underline. A host computer or local microcontroller inputs data with a pair of *clock* and *data* buses in the usual manner.

Internal control registers set the position, colors, signal polarity, custom data versus line 21, channel selection, and row address. See the Philips data book for the exact command codes to be used.

If any of the horizontal, vertical, or blanking inputs are absent from your video source, add a National Semiconductor LM1881 video sync separator or one of the CD1881s made by Harris Semicondutor. There is a separate or "stand-alone" mode that does not need a computer, but this mode is limited to the stock display of line 21 captions only. Be sure you have the data book on hand before you start using this device. Give me a call if you need any more technical applications help.

Thoughts on brain implants

My tech helpline receives calls on a wide variety of topics. A surprisingly large number of my callers genuinely believe they have been the unwilling recipients of brain implants. It seems there are even implant support groups and networks. There has been a multi-billion dollar lawsuit aimed at a big transportation company and a foreign government. The "men in black" and extraterrestrials are sometimes blamed—as are disgruntled divorcees.

The obvious step these folks should take if they believe they have this problem is to see if extended time in a cave can make any difference. Or they can take long-term herbal remedies such as *Ginko Biloba* or *CoEnzyme Q10*.

Now, it's easy to dismiss such claims out of hand. But I don't like to discourage people calling me about most off-the-wall topics, regardless of how bizarre they seem—at least not until I find out what "real" science and "real" engineering have to say about the subject. If, after my careful research, the topic obviously becomes a "useful adjunct to porcine cleanliness," then so be it.

Well, the amazing answer is that implants are routinely available as off-the-shelf operations at modest cost. But the most popular models only hold your net worth and Social Security Number. They only measure how hot you are under the col-

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Phone or write your Hardware Hacker questions to:

Don Lancaster
Synergetics
Box 809-EN
Thatcher, AZ, 85552
(602) 428-4073

For fast PSRT access, modem (800) 638-8369. On prompt, enter JOINGENIE. When asked for the keyword, enter DMD524.

Internet email access link:
SYNERGETICS@GENIE.GEIS.COM.

lar. And they only have a useful range of several inches. Most applications are totally unlicensed and unregulated.

I strongly believe that one of the next major hardware hacking arenas will involve the direct computer-to-brain interface. First and foremost, because direct access offers the prospect of immortality—at least as far as your thoughts and feelings go. Typical used car dealers would gladly pay $44.95 for a box with three buttons on it that is marked ENTER LOT, BUY, and LEAVE.

Politicians would spring an extra $10 if the same box had a 100-mile range. Historians would appreciate its "instant replay" features, as would crime investigators. Most medical professionals would definitely welcome new routes towards effective cures.

Especially for addictions.

The more conservative elements of society are bound to be horrified at the prospect of direct personal access to brain pleasure centers. "Press one for psychedelics; two for sex; three for rapture; or four for a coconut-anchovy pizza." This appliance would instantly obsolete most of the more popular forms of entertainment.

Obviously the present problems with direct access include the input/output scheme and understanding the brain's operating system and its instruction set. But there's bound to be a system monitor in there somewhere. It can't be any worse than the Unix operating system. But the solutions to these problems are a lot closer to realization than you think—and clearly solvable.

The leading manufacturer of new inplants is Bio Medic Data Systems. Its DAS series is intended primarily for laboratory animals. The implants are normally located in the animal's back or shoulder, rather than its brain. These have a read, record, and write capability. Stock models can log body temperature. The usual range is normally only a few inches. One major supplier of implantable integrated circuits is Dallas Semiconductor.

Professional and trade journals that report on this subject include *Identification Journal*, *Automatic ID News*, *Access Control*, and *I.D. Systems*. Clearly, the human brain is sure to become the ultimate hack.

Another contest

For this month's contest, just tell me in 175,000 words or less all the possibilities and consequences of the "real soon now" direct brain access that is almost certainly to occur sooner or later.

There are about a dozen of my *Incredible Secret Money Machine II* books set aside for the better entries, with an all expense paid (FOB, Thatcher, AZ), *tinaja quest* going to the very best of all. Entries must be *written* and sent to me here at *Synergetics*.

Sinewaves—old and new

A new algorithm for generating digital sinewaves showed up in the December 1994 *Byte* on pages 217 to 218. This is one of the finest examples of elegant simplicity I have ever seen. Amazingly, it takes only two registers and six bytes of working eight-bit code to set up the PIC micros!

I have repeated Byte's algorithm in Fig. 2, and included some simple PostScript code which will let you interactively explore, model, analyze, or plot this new sinewave scheme. This method is extremely attractive for use in one of many small microcontrollers.

Before I explain the details, I think it would be a good idea to review some of the standard methods for generating sinewaves. I've long been both a student of and developer of sinewave sources.

In the *bandpass filter* method, you wrap an amplifier with unity loop gain around a resonant coil and capacitor. If you tap the coil for feedback, you have a *Hartley* (or "hardly") circuit for your oscillator. Tap the capacitor instead, and you'll end up with a *Colpitts* (or "polecats") circuit.

A *Wein Bridge* includes an RC network that can be considered as overlapping highpass and lowpass filters. Put just enough gain around this one, and you get a sinewave out. For "just enough" gain, you will need some kind of amplitude stabilization scheme. This could be the nonlinear resistance of a pilot incandescent lamp.

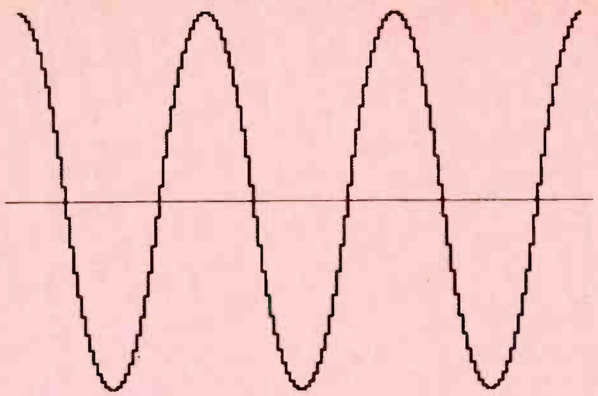
Almost any repetitive waveform consists of a fundamental sinewave and several harmonics. With the *filter* method, you generate a waveform and then pass the output through a lowpass or bandpass filter to extract the fundamental wave. Starting with symmetric waveforms gets rid of all the even harmonics—particularly that troublesome second harmonic.

While square waves are an obvious starting waveform, the third harmonic is a horrific 0.33 of the fundamental. It is only 10 decibels down. A triangle wave's third harmonic is only 0.11 of the fundamental, and it can be a lot easier to process. Filtering can become tricky very rapidly if the frequency shifts significantly.

Those *triangle game* methods all start with a triangular wave that you play around with. If you softly clip the "points", you'll get a sinewave out. Or, you can add a new triangle wave that has three times the frequency and 1/9th the amplitude to cancel out the original third harmonic. It will leave that easily processed fifth harmonic at -1/25th down.

The horribly obsolete *breakpoints* method is related to triangle games. It constructs an analog sinewave with straight-line approximations.

The *double integrator* seems the purest form of sinewave generator. Start with any waveform "S," add up, or continuously integrate the area under "S" to produce a new waveform "C". Then integrate "C" and invert it. Make this inverted and integrated "C" output your "S" input, and you've got yourself a pure sinewave.



THE ALGORITHM:

1. Initialize a SIZE stash to a magic value.
2. Initialize a SPEED stash to zero.
3. If SIZE is positive, decrement SPEED. If SIZE is negative, increment SPEED.
4. Add SIZE to SPEED to get the new SIZE.
5. Use your digitally generated sinewave.
6. Repeat steps 3-5 as required.

POSTSCRIPT DEMO:

```
% Draw a 48 step digital sinewave...
200 300 translate                          % set position on page
/steps 48 def                              % set steps per cycle
/size 72 def                               % set zero to peak size
/speed 0 def                               % initialize speed
0 size moveto                              % move to starting point
1 1 size {                                 % start a for loop
  /val exch store                          % save position
  /speed speed size 0 gt {-1}{+1}          % do the algorithm
  ifelse add store
  /size size speed add store
  1 0 rlineto                              % draw horizontal step
  val size lineto                          % draw vertical step
      } for                                % complete loop
stroke showpage                            % draw it and print it
```

FIG. 2—AN AMAZINGLY COMPACT AND EFFICIENT digital sinewave generator. Only six machine language bytes are needed. When magnified, the fattened waveshape reveals a 4% distortion.

Guaranteed results.

Why does this happen? Because you just set up a big, old, *differential equation* whose solution is always a pure sinewave. And "S," stands for the *sine*. And "C" for the quadrature (90° phase-shifted) *cosine*. This method is often called the *analog computer* method.

There is more on the double integrator in my *Active Filter Cookbook*. One of the variations on this is known as a *state variable filter*.

All of these sinewaves can be generated by analog or digital methods. The advantage of digital methods is that they offer frequencies that are both stable and easily changed. They can be instantly swept with ease, usually without any nasty transients.

Moreover, no large, costly, and field-sensitive coils are needed. Amplitude is easily controlled and inherently stable. In addition, distortion products and phase are precisely known. Today, digital methods are accomplished by smaller, cheaper, better, and lower powered circuits.

The *walking ring* is an example of an older but still rather elegant hybrid sinewave generator. Connect a walking-ring counter and some carefully selected summing resistors to *all but one* of those output phases. Introduce a digital clock signal and the output is an analog sinewave with surprisingly low distortion. The full details of this are in my *CMOS Cookbook*.

Table lookup is the most popular "pure" digital methods in use today. Start with a direct input signal or an up-down counter and route the signal to an EPROM or other read-only memory that looks up the sine of the counter state representing the present angle. This method is very fast, but it requires a lot of memory for reasonable accuracy. Certain symmetry and interpolation tricks can be used to ease the memory requirement.

A frequency synthesizer can use a *phase accumulator*, which is just a phase adder in front of one or more lookup tables.

Almost any waveform can be represented by a *power series*. For instance, the cosine of x can be calculated by:

$$1 - x^2/2! + x^4/4! + \ldots$$

For angles up to about 60°, you need only the square term. But more terms will be needed for higher angles. The power series calculations take time and have precision limits. Variations on these power series methods are applied in most math coprocessor circuits. Sinewaves can be related to exponentials and similar functions. The details can become complex rapidly. There is also the obscure and slow *rate multipler* scheme for generating digital sinewaves, but it is no longer widely applied.

THE ALGORITHM:

1. Initialize a SIZE stash to magic value #1.
2. Initialize a SPEED stash to zero.
3. Select a magic value #2 for CLIP.
4. If SIZE is positive, decrement SPEED.
   If SIZE is negative, increment SPEED.
5. Set FIX to SPEED.
   If FIX > +CLIP, then FIX = +CLIP
   If FIX < -CLIP, then FIX = -CLIP
6. Add SIZE to FIX to get the new SIZE.
7. Use your digitally generated sinewave.
8. Repeat steps 4-7 as required.

A POSTSCRIPT UTILITY:

```
% Calculate a 48 step low distortion digital sinewave...

/steps 48 def                        % set steps per cycle
/size 64 def                         % set zero to peak size
/speed 0 def                         % initialize speed
/clip 8 def                          % initialize clip

1 1 size {                           % start a for loop

  /val exch store                    % save position

  /speed speed size 0 gt {-1}{+1}    % start the algorithm
  ifelse add store

  speed dup clip gt                  % clip a copy of speed
    {pop clip} ifelse
  speed dup clip neg lt
    {pop clip neg} ifelse

  /size exch size add store          % finish the algorithm

  % use your sinewave here

      } for                          % complete loop
```

FIG. 3—A LOW DISTORTION VARIATION that requires a few more bytes. The third harmonic might be eliminated completely.

NAMES AND NUMBERS

Access Control
6151 Powers Ferry Rd NW
Atlanta GA 30339
(404) 955-2500

Amateur Seismologist
2155 Verdugo Blvd #528
Montrose CA 91020
(818) 249-1759

American Laboratory
30 Controls Drive
Shelton CT 06484
(203) 926-9300

Antique Automobile Radio
700 Tampa Road
Palm Harbor FL 34683
(800) 933-4926

Antique Radio Classified
PO Box 802
Carlisle MA 01741
(508) 371-0512

Automatic ID News
7500 Old Oak Blvd
Cleveland OH 44130
(216) 243-8100

Bio Medic Data Systems
255 W Spring Valley Avenue
Maywood NJ 07607
(800) 526-2637

Jim DuBois
330 State Road 101
Amherst NH 03031
(603) 673-3645

GEnie
401 N Washington St
Rockville MD 20850
(800) 638-9636

GeoSpace
7334 N Gessner
Houston TX 77040
(713) 939-7093

The new method

My reaction when I first saw the code was "That can't work!" There simply can *not* be any overlooked fundamentally new sinewave method today. That would be about the same as discovering a new trigonometric identity.

However, it turned out that what I

Handmade Electronics
1825 Roth Ave
Allentown PA 18104
(610) 432-5732

Horn Speaker
PO Box 1193
Mabank TX 75147
(903) 848-0304

ID Systems
174 Concord St
Peterborough NH 03458
(603) 924-9631

Identification Journal
2640 N Halsted St
Chicago IL 60614
(312) 528-6600

National Semiconductor Corp.
2900 Semiconductor Rd
Santa Clara CA 95052
(800) 272-9959

NewTek
1200 SW Executive Dr
Topeka KS 66615
(800) 847-6111

Microchip Technology
2355 W Chandler Blvd
Chandler AZ 85224
(602) 963-7373

RF Design
6300 S Syracuse Wy #650
Englewood CO 80111
(303) 220-0600

Philips
PO Box 3409
Sunnyvale CA 94088
(408) 991-2000

AG Tannenbaum
PO Box 110
E Rockaway NY 11518
(516) 887-0057

really have here is an extremely fast and compact (but slightly flawed) variation on the double integrator method. You can view it as a *numeric sequence generator* that happens to trace out a waveform that's roughly similar to a real sinewave.

Take an eight-bit stash and call it *size*. Take a second eight-bit stash and call it *speed*. Select a magic initial value for *size* :0.72 will do. Set *speed* to zero. Now apply the following rules:

- If *size* is positive, *decrement* the *speed* value.
- If it is not, *increment* the *speed* stash.
- Finally, add *speed* to *size* to find the new *size* value.

This method does *not* generate a true sinewave. Rather, it creates a "partially hydrogenated" cosine wave with a little extra fat on its leading edges.

Out of the box, your third harmonic distortion is typically in the 4 %. This might or might not be acceptable. Four percent just barely shows up on a graphic plot, but its harshness is easily spotted when you listen to it as audio. Many applications cannot tolerate this level.

Thankfully, there are *zero* even harmonics. Often, there will be zero DC offset. This distortion is caused by the fact that *speed* is supposed to be a cosine wave, and the algorithm.

Improving it

I could not leave well enough alone. This beast is highly obsessive, like the old shop joke of one machinist drawing out the world's thinnest wire. Well, the second machinist then drilled the world's smallest hole down through it. Finally, of course, the third machinist tapped that hole.

It turns out there is a simple way to dramatically reduce the distortion. You might completely eliminate the third while significantly reducing the rest of them. All those higher odd harmonics are usually easy to filter out. Of course, this might be at the cost of speed and code length. Exact details will vary with the implementation selected.

Once again, the cause of all the original distortion is the generation of a triangle wave, which is called a cosine wave. Admittedly, real cosines become difficult to deal with when you are only allowed to use six bytes worth of small integers. But if you chop the top and bottom off the triangle, you can get a lot closer to perfection. This is shown in Fig. 3.

Any repetitive waveform can be analyzed by *Fourier Series* techniques. The general purpose PostScript language is ideal for this analysis. I'll discuss the details in another column. However, Fig. 4 reveals several magic amplitude and distortion values for both algorithm versions.

If a DC offset is present in the listed values, it's half a step one way or the other. Capacitor coupling can eliminate this, when permitted.

Note that *none* of the 128 or higher amplitude sequences can be realized as single eight-bit words. Because of state zero and negative values, 257 or more states are involved. PostScript, of course, handles those higher values with ease and aplomb. There are several other possible amplitudes. These either have extra DC in their outputs or worse distortion is present.

I am fairly certain I've shown all possible eight-bit steps-per-cycle values. These are just four times the maximum unclipped *speed* values. An ultralow distortion variant is shown in Fig. 5. It offers a low 0.24 % distortion, and most of that is easily filtered seventh harmonic.

But this takes a few extra bytes of code and has limited sets of useful values. Moreover, There is an aesthetically unsatisfactory wrinkle in the sine plot as well. In one variation, the fifth is 62 dB down—before any filtering!

A much more detailed analysis, full sequences, and ready-to-run code appears in my files FOURIER.PS and NEWSINE.PS on *GEnie* PSRT. The *Golly Gee Mister Science* tinaja questing society has just announced its award for the best data book rear cover. The award goes to Philips for the latest update of its *Desktop Video Data Handbook*.

Philips also has the best front cover, by far. Moreover, the inside of the book ain't half bad either. This gem is crammed full of neat products on digital TV, teletext for video capture, sync generators, and color coders.

steps per cycle	peak amplitude	clipping level	dc offset present?	3rd harm. distortion	total harm. distortion
8	2	none	no	5.74%	9.76%
12	4	2	no	0%	2.72%
12	5	none	yes	4.92%	5.32%
16	8	3	yes	1.79%	2.18%
16	8	none	no	4.33%	4.65%
20	10	3	yes	1.56%	2.11%
20	12	none	yes	4.09%	4.29%
24	16	4	no	0%	1.08%
24	20	none	no	3.96%	4.12%
28	22	5	yes	0.96%	1.25%
28	24	none	yes	3.89%	4.03%
32	28	5	yes	0.90%	1.42%
32	32	none	no	3.84%	3.98%
36	36	6	no	0%	0.94%
36	40	none	yes	3.8%	3.94%
40	46	7	yes	0.67%	1.03%
40	50	none	no	3.79%	3.81%
44	52	7	yes	0.63%	1.19%
44	60	none	yes	3.81%	3.89%
48	64	8	no	0%	0.90%
48	72	none	no	3.77%	3.88%
56	76	9	yes	0.51%	0.94%
56	84	none	yes	3.76%	3.87%
56	86	9	yes	0.49%	1.08%
56	98	none	no	3.75%	3.86%
60	100	10	no	0%	0.88%
60	110	none	yes	3.74%	3.85%
64	116	11	yes	0.41%	0.91%
64	128	none	no	3.74%	3.84%
68	126	11	yes	0.41%	1.02%
68	138	none	yes	3.76%	3.84%

FIG. 4—DATA VALUES for the more interesting and useful digital sinewave generators. Both "regular" and "low-distortion" schemes are shown.

New tech Literature

Also from Philips are new editions of its *Audio/Radio*, and *Wireless* data handbooks. From *Analog Devices*, there is the incredibly fat new *Design-In Reference Manual*.

There is a fascinating article on *molecular* computers based on DNA strands in the November 11, 1994 issue of *Science*, pages 993 and 1021 to 1023. One of the problems solved by this DNA computer was the determination of an optimum route for a traveling salesman between a number of cities.

The problem was solved a thousand times faster than it could be solved on the the best existing supercomputer. The biological computer needs only a fraction of the space and energy of a supercomputer. The secret lies in using *billions* of parallel molecular coprocessors.

A mind-boggling breakthrough in micropower receivers is described in the December, 1994 *R. F. Design*. Look for it on pages 32 to 44. These receivers easily extend the max-

```
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% Personal use permitted so long as this header remains present and intact.

% Variation #1 has 60 steps per cycle and a 96 peak amplitude.
% The DC term and harmonics 2,3,4,6,8,9,10, and 12 are ZERO!

% The fifth harmonic distortion is 0.061%. Total distortion is 0.342%.

/size 96 def
/speed 0 def

0 1 60 {
        /val exch def
        /speed speed size 0 gt {-1}{+1} ifelse add store
        /size size speed dup 10 eq {pop 6} if dup -10 eq {pop -6} if
        dup 10 gt {pop 10} if dup -10 lt {pop -10} if add store

        % use your sinewave here

       } for

% Variation #2 has 60 steps per cycle and a 97 peak amplitude.
% The DC term and harmonics 2,3,4,6,8,9,10, and 12 are ZERO!

% The fifth harmonic distortion is 0.162%. Total distortion is 0.247%.

/size 97 def
/speed 0 def

0 1 60 {
        /val exch def
        /speed speed size 0 gt {-1}{+1} ifelse add store
        /size size speed dup 10 eq {pop 7} if dup -10 eq {pop -7} if
        dup 10 gt {pop 10} if dup -10 lt {pop -10} if add store

        % use your sinewave here

       } for

% Variation #3 gives you 48 steps per cycle and a 62 peak amplitude.
% The DC term and harmonics 2,3,4,6,8,9,10, and 12 are ZERO!

% The fifth harmonic distortion is 0.149%. Total distortion is 0.241%.

/size 62 def
/speed 0 def

0 1 48 {
        /val exch def
        /speed speed size 0 gt {-1}{+1} ifelse add store
        /size size speed dup 8 eq {pop 6} if dup -8 eq {pop -6} if
        dup 8 gt {pop 8} if dup -8 lt {pop -8} if add store

        % use sinewave here

       } for
```

FIG. 5—ULTRALOW DISTORTION digital sinewaves depend on black magic.

imum range for legal and unlicensed transmitters to 1000 feet and beyond.

The secret to this tuned radio frequency (TRF) variant is two cascaded, high-gain, radio-frequency amplifiers; *only one of them is switched on at any time!* Its performance greatly exceeds the best of the superregenerative receivers or single conversion superhetrodyne receivers. Moreover, there are zero radiation and image problems.

The *Amateur Seismologist* offers low-cost earthquake detectors and personal computer support software. Professional geophones are available from *GeoSpace*.

Outstanding buys for precision CAD/CAM steppers, X-Y tables, and similar bits and pieces are offered by *Jim DuBois*. His stock is mostly one-of-a-kind used and surplus products.

Here are some more antique radio resources: The *Horn Speaker* is a new labor-of-love tabloid alternative to *Antique Radio Classified*. Hard-to-find classic repair manuals and *Photofacts* are offered by *A. G. Tannenbaum*. He also stocks, wonder of wonders, 1945 edition *Radiotron Designer's Handbooks* at $15.

Replacement automobile radio vibrators are offered by *Antique Automobile Radio*, while audio vacuum-tube components are sold by *Handmade Electronics*.

The secrets to starting your own technical venture appear in my *Incredible Secret Money Machine II*. See my nearby *Synergetics* ad. I've also accumulated a large stock of classic Apples computers and replacement parts. They are cheap enough for use as dedicated controllers. Write, E-mail, or call me for a complete listing.

Here is a reminder that unique downloads, freebie insider secrets, catalogs, and technical help are available on *GEnie* PSRT. A ten-hour free trial offer is available if you sign up with a credit account; see my *Need Help?* box.

As usual, most of the resources I've mentioned appear in the *Names & Numbers* sidebar. Be sure to check this sidebar first before calling our no-charge tech helpline.

Let's hear from you. Ω

DRAWING BOARD

A couple of "old" circuits, and a brand new topic.

ROBERT GROSSBLATT

I've been getting a lot of mail about a series of columns I did on video and video descrambling. When the series was reprinted, a gates-only way of decoding the magic line numbers (24 and 257) was omitted. When I was doing the series, I showed how to decode those lines with an EPROM and, several months later, published two schematics sent in by readers who had done the same thing using gates.

In the spirit of completeness, I'm going to reprint these here and, once again, give credit where credit is due.

The first circuit, from David Siegel of Livonia, Michigan, is shown in Fig. 1. It's a pretty slick design. The second decoder is from Chris Carson of Ottowa, Ontario. His design is a bit more complicated, as you can see in Fig. 2. One nice feature is that only one pin is used for the line indicator. This is handy if you want the rest of your descrambler to have the start and end of the vertical interval to be indicated on a single line.

The descrambling series was never intended as a construction article for a working SSAVI descrambler. Instead, it was meant to be a starting point for experimentation and for those who want to understand video scrambling techniques. Different cable companies use different variations on the basic scheme. In New York City, for example, there are two cable companies, both owned by the same parent company Time-Warner. While the scrambling method for each is similar, they differ in how the invert the video. The video scrambling you encounter will undoubtedly be different.

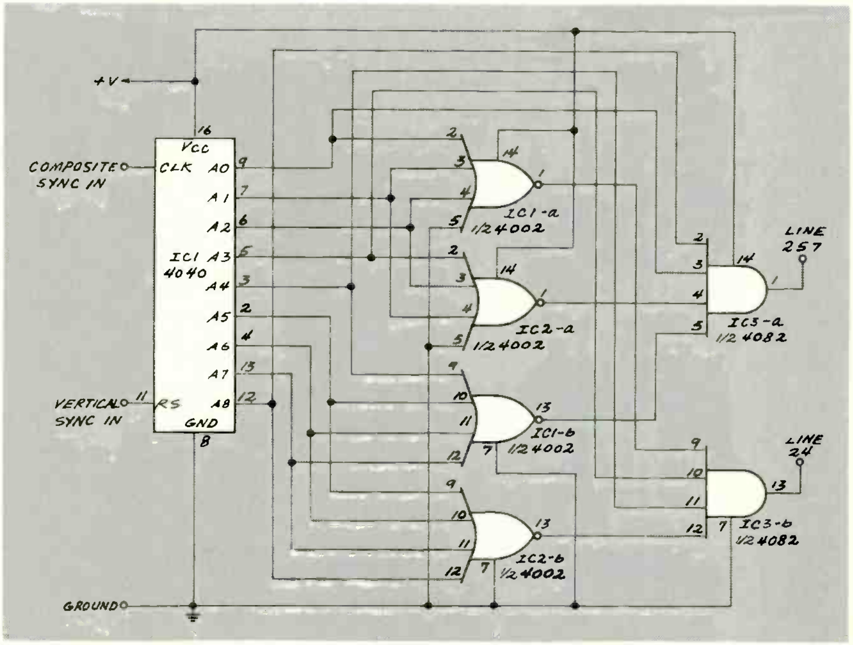


FIG. 1—THIS CIRCUIT WILL DECODE line numbers 24 and 257.

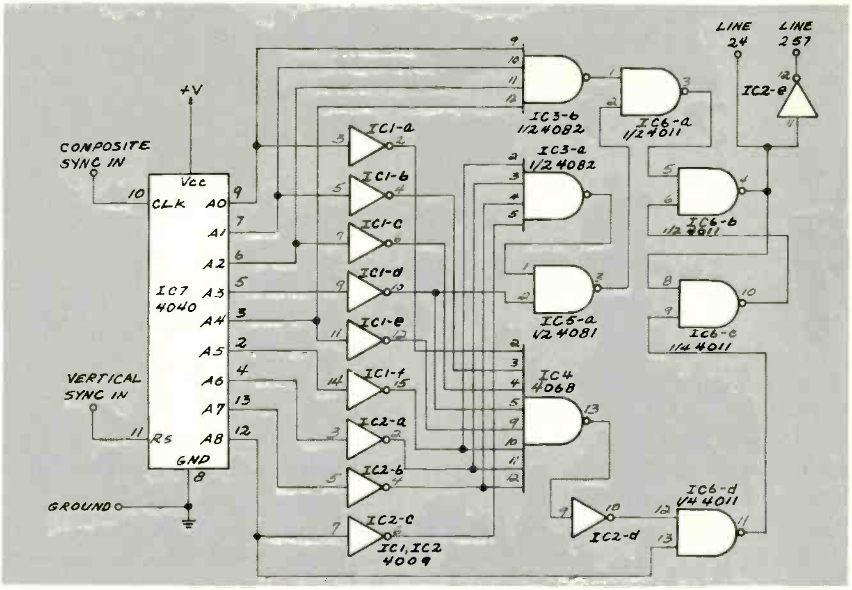


FIG. 2—ANOTHER LINE DECODER. This one uses only one pin for the line indicator.

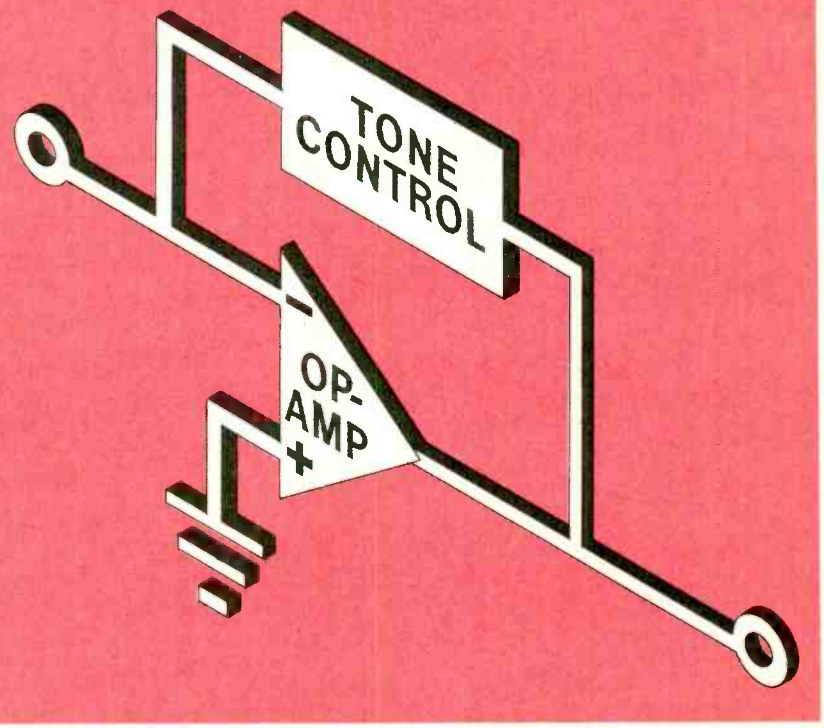
Audio

Regular readers might remember that I've mentioned several times that I have a house in the country. Now, I'm not going to say where it is, but I will tell you that the winters up there are really cold and, since we go up nearly every weekend, winter weekends are usually indoor weekends. I like to have some project to work on, and my latest one is to wire the house for sound. I thought this would be simple to do, but I should have known better.

Continued on page 91

RAY MARSTON

ACTIVE AUDIO FILTERS for Signal Processing and Control



Learn about active filters in audio signal processing and control, and apply that knowledge to your circuit designs

THIS THIRD ARTICLE IN A SERIES ON active filters focuses on audio signal processing and amplitude control circuits. The last article, in the February 1995 issue of *Electronics Now*, page 65, discussed popular passive control networks including high- and low-pass filtering circuits. This article picks up where that article left off with a discussion of active tone-control circuits, and it goes on to explain amplitude-regulating circuits.

Active tone controls

An active tone-control circuit can be made by connecting a passive tone-control network to the negative feedback loop of a linear amplifier, typically an operational amplifier. This circuit provides signal gain rather than attenuation.

Tone-control networks can be simplified versions of Fig. 15 in the February 1995 article. However, they are more likely to be based on the alternative passive tone-control circuit shown here as Fig. 1. This circuit's performance is comparable, but requires fewer components, and it includes two linear control potentiometers.

If the input signals to the circuit in Fig. 1 are low enough so that capacitors C1 and C2 act like open circuits, the output signal amplitudes are controlled entirely by resistor R5. This occurs because resistor R6 is isolated from the output by capacitor C2.

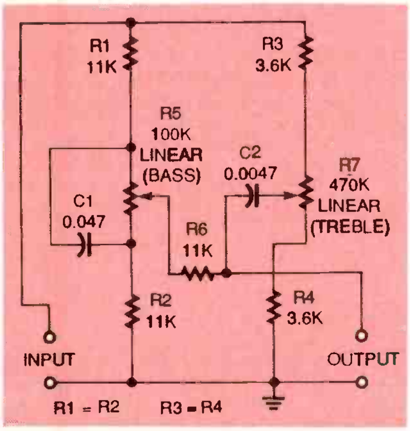


FIG. 1—ALTERNATIVE TONE-CONTROL circuit that includes two potentiometers.

However, at input frequencies that are high enough so that the two capacitors act like short circuits, the output signal amplitudes are controlled entirely by resistor R6. In this situation, resistor R5 is short circuited by C1.

The low-frequency (*bass*) circuit cutoff is determined by the values of R1 and C1, and the high-frequency (*treble*) cutoff is determined by C2 and the values of R1 to R3.

Figure 2 illustrates how the network in Fig. 1 network is integrated into an active tone control circuit that can provide up to 20 decibels (dB) of boost or cut to bass or treble signals.

The circuit shown in Fig. 3, although similar to that of Fig. 2, is more versatile. It has an additional filter control network that is centered on the 1-kHz *midband* of the audio spectrum. This network permits the midband to be boosted or cut by as much as 20 dB.

Graphic equalizers

The more sophisticated graphic equalizer tone-control system consists of a many parallel-connected, variable-response filters that overlap and have narrow-passbands to cover the entire audio spectrum. This cir-

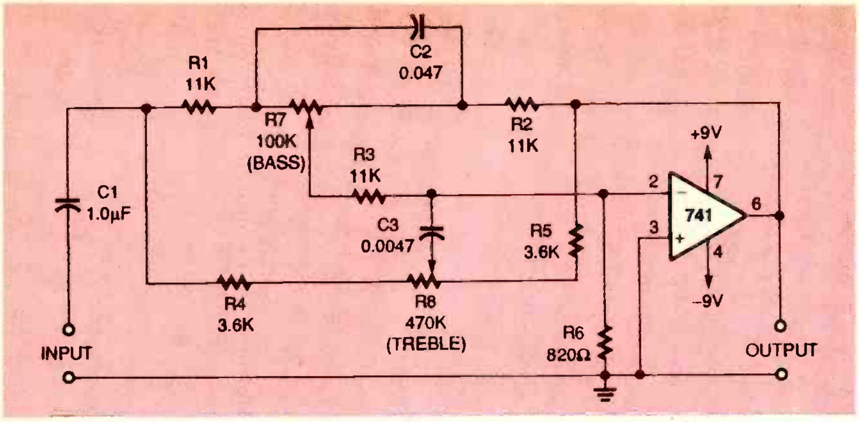


FIG. 2—ACTIVE TONE-CONTROL CIRCUIT that includes the Fig. 1 circuit.

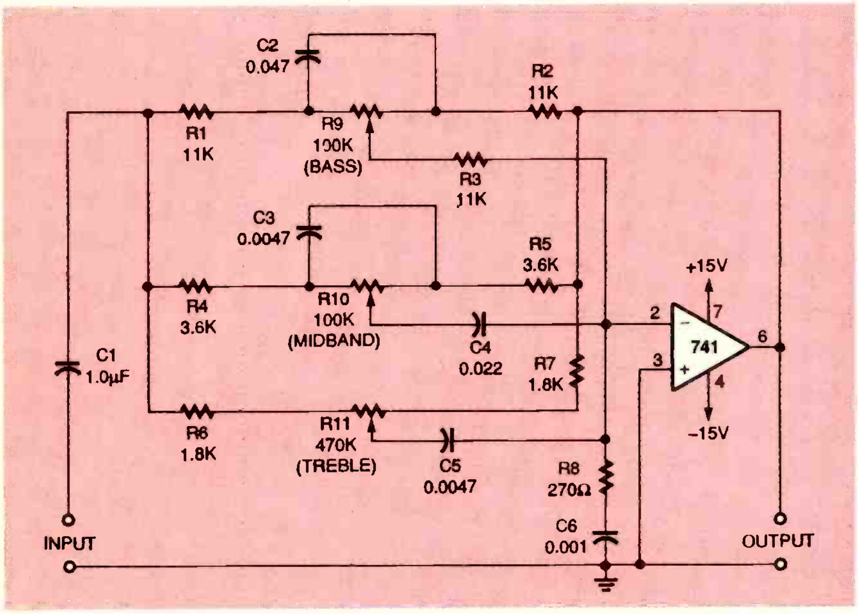


FIG. 3—THREE-BAND ACTIVE TONE-CONTROL control (bass, midband, treble).

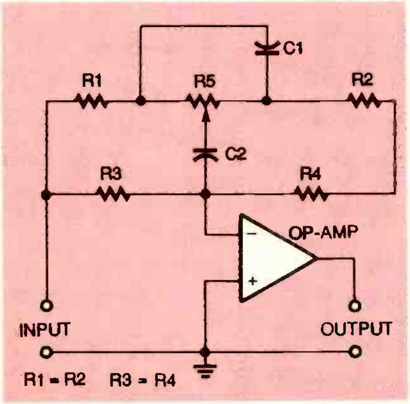


FIG. 4—TYPICAL OCTAVE (GRAPHIC) equalizer section.

cuitry permits tailoring an amplifier circuit's spectral response to suit individual needs. The filter center frequencies are typically spaced at one octave intervals. As a result, those systems are also called *octave equalizers*.

Figure 4 is the schematic for a typical octave (graphic) equalizer section. It is similar to the active tone-control circuit shown in Fig. 2, except that *treble control* network consisting of C2, R3, and R4 is fixed rather than variable, and the bass and treble cutoff frequencies are spaced closely. As a result, the two response curves overlap.

Consequently, the circuit in Fig. 4 circuit acts as a narrowband filter with a center frequency response that is fully variable between +12 dB (full boost) and −12 dB (full cut) by adjusting potentiometer R5.

Figure 5 shows how the circuits of Figs. 3 and 4 are interconnected to form a high quality, ten-band graphic equalizer. The ten equalizer sections are in parallel, and their outputs are summed in the output stage that includes the IC11 operational amplifier.

The operational amplifiers in this circuit can be the industry-standard LM741 or comparable dual versions such as the LM747. Stereo amplifier systems visually contain two complete circuits of the kind shown in Fig. 5.

RIAA equalization

Phonograph records are no longer the preferred media for storing and reproducing music, having been replaced years ago by tape cassettes and compact discs (CDs). Nevertheless, many people still own turntables for playing 33 RPM long-playing record (LPs) or 45 RPM records. The pickup arms of those record players include either ceramic, crystal, or magnetic cartridges and needles that are in direct contact with the grooves in the records.

The ceramic and crystal cartridges were inexpensive, but they produced large-amplitude and fairly linear outputs suitable for low-priced record players. However, magnetic cartridges were preferred for high-performance, high-fidelity stereo systems. Although their output is low, and they have nonlinear frequency response characteristics, their corrected output provides more faithful music reproduction.

The characteristics of any record playback system can be determined with a test record containing a three-decade span of sinewave tone signals with constant amplitude from 20 Hz to 20 kHz. A quality magnetic cartridge should generate a nonlinear frequency response that rises at a rate of 6 dB per octave (equal to 20 dB per decade). Thus the output signals would be weak at 20 Hz, but would be one thousand times greater (equal to +60 dB) at 20 kHz.

This nonlinear frequency response is an inherent characteristic of all magnetic pickups because their output voltage is directly proportional to the pickup needle movement rate

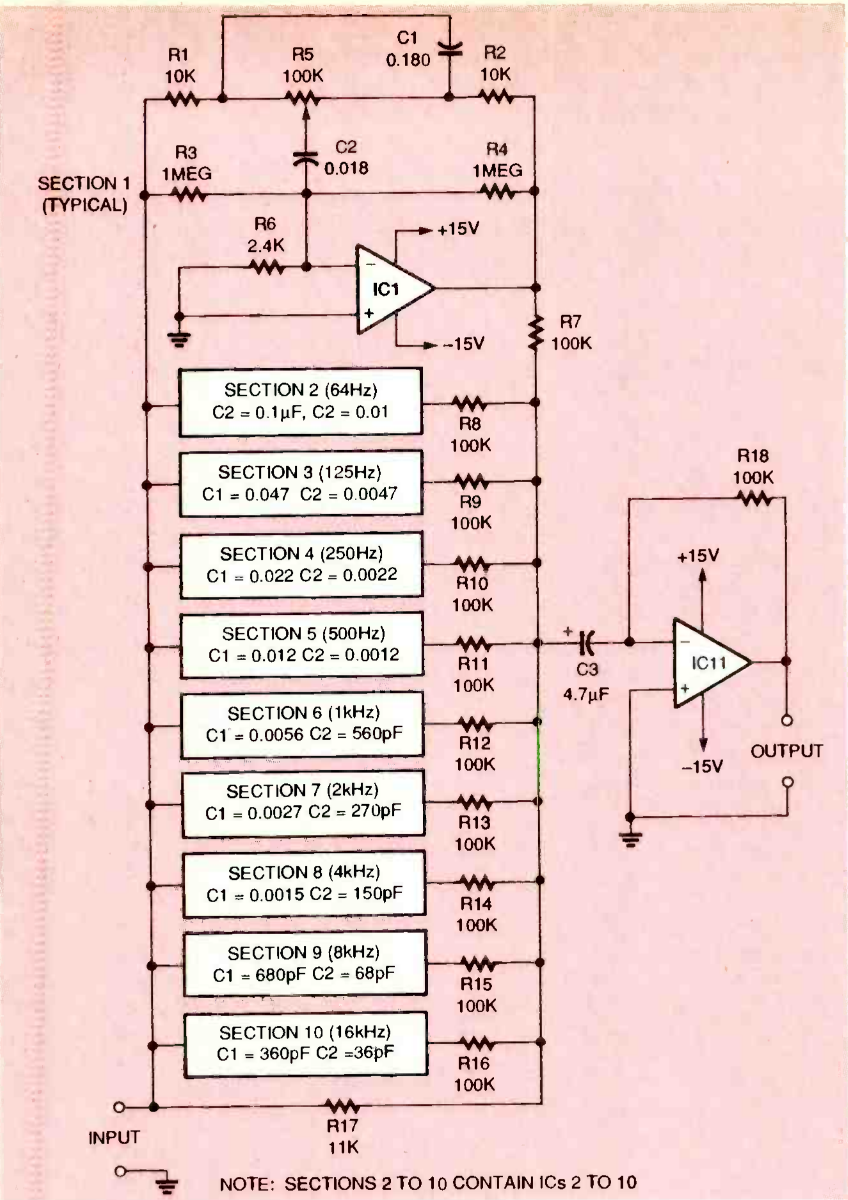


FIG. 5—TEN-OCTAVE (GRAPHIC) equalizer circuit.

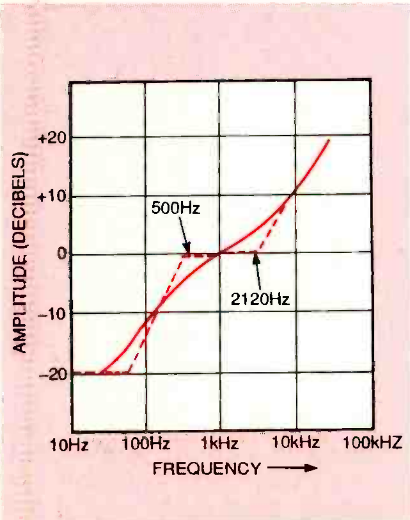


FIG. 6—TYPICAL PHONOGRAPH record playback frequency response curve.

which, in turn, is proportional to recording frequency.

Phono disk recording equipment usually did not provide truly linear frequency response. To enhance the effective dynamic range and signal-to-noise ratio of records, frequencies below 50 Hz and those in the 500-Hz to 2.12-kHz midband range were recorded nonlinearly in accordance with a standard curve defined by the Recording Industry Association of America (RIAA).

This nonlinearity causes a midband drop of 12 dB when the record is played through linear-response ceramic or crystal pickups, but this decrease was too small to be objectionable in most low-end record players.

Figure 6 shows a plot of a typical phonograph record playback frequency response curve as a solid line and dotted line superimposed on the solid line that represents the ideal response curve. The ideal (dotted-line) curve is flat to 50 Hz where it rises at a 6 dB/octave rate to 500 Hz. It remains flat from 500 Hz to 2120 Hz, then rises again at a 6 dB/octave rate to about 20 kHz.

When a record is played through a magnetic pickup in a high quality hi-fi system, the output of the pickup is preamplified before going to the power amplifier. The preamplifier must have a frequency equalization curve that is the exact inverse of that shown in Fig. 6, so that an overall linear response is obtained. Figure 7 shows the RIAA equalization

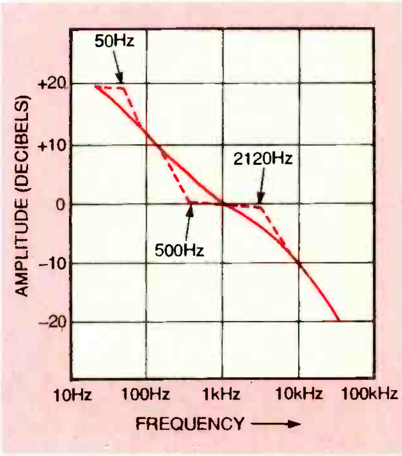


FIG. 7—RIAA PLAYBACK equalization curve.

curve. It is the inverse of recording curve shown in Fig. 6.

RIAA preamplifier

Magnetic pickup cartridges are low-sensitivity devices that give typical midband outputs of only a few millivolts. Consequently, their output signals must be preamplified by a dedicated, low-noise preamplifier integrated circuits rather than general-purpose operational amplifiers. A schematic for a preamplifier with integral RIAA magnetic-pickup equalization is shown in Fig. 8. The circuit includes an LM381 low-noise, dual preamplifier IC.

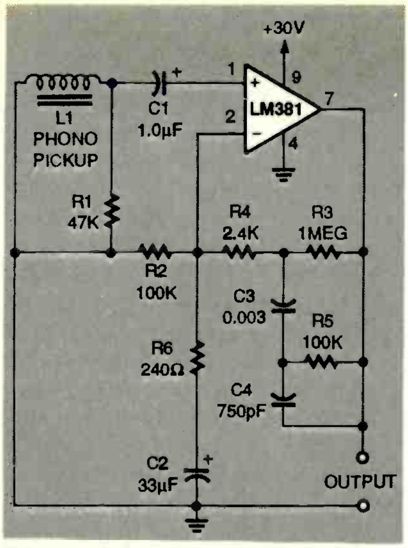


FIG. 8—LOW-NOISE MAGNETIC phono cartridge preamplifier that includes RIAA equalization.

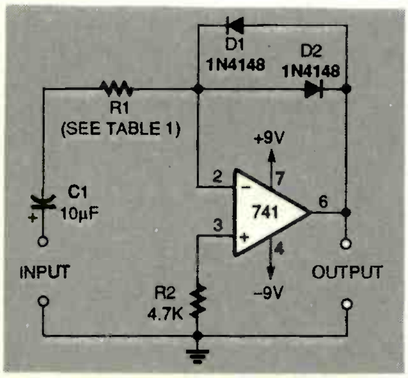


FIG. 9—NONLINEAR (SEMILOG) amplifier based on the 741 operational amplifier.

As an alternative, a National Semiconductor LM387, another low-noise, dual preamplifier will work in the circuit. Both the National LM381 and LM387 are suitable as amplifiers in audio-tape playback preamplifiers.

The pin numbers shown in Fig. 8 are those of the first half of the LM381, packaged in a 14-pin DIP. (The LM387 is packaged in an 8-pin DIP.) Because two of these preamplifier circuits are needed in a stereo audio system, both sections of the dual preamplifier ICs are used.

The LM381 has a high, open-loop gain of 112 dB, and a total input noise rating of 0.5 microvolts. Its output voltage swing equals the supply voltage minus 2 volts and it has a wide power bandwidth of 75 kHz, 20 volts peak-to-peak. The LM387 is similar to the LM381 except that it has an open-loop gain of 104 dB and a total input noise rating of 1.0 microvolt. The amplifiers in both ICs are electrically independent of each other.

The LM381 in Fig. 8 is configured as a noninverting amplifier. Negative feedback is applied from the output to the inverting input terminal. The voltage divider consisting of resistors R3 and R4, and the network formed by resistor R6 and capacitor C2 determines AC signal gain.

At the audio frequency midband (centered on 1 kHz) capacitors C2 and C3 have low impedances and C4 has a high impedance. As a result, AC gain is determined principally by the value of resistor R5 divided by R6, and it equals about 400. At lower frequencies, the impedance of C3 becomes significant and it causes AC gain to increase until, at very low frequencies, it is limited to 4000 by the ratio of the value of resistor R3 with respect to R6.

By contrast, at high frequencies, the impedance of C4 falls significantly, shunting R5. This causes the AC gain to decrease until, at very high frequencies, it is limited to 10 by the ration of the values of R4 to R6. The signals form the magnetic pickup cartridge are AC coupled to the LM381 by C1.

Nonlinear amplifiers

An operational amplifier will act as a nonlinear amplifier if a nonlinear component is included in its negative feedback network. Figure 9 shows two square-law response (nonlinear) feedback elements, a pair of diodes connected back-to-back in the feedback loop.

When small signals are applied to this circuit, the diodes act as infinite resistance (open circuits), so circuit gain is high. However, when large signals are applied, the diodes act a low resistances, so circuit gain is low.

The gain follows a semi-logarithmic function, and circuit sensitivity can be varied by altering the value of resistor R1. Table 1 summarizes the circuit performance with two different values of R1—1 and 10 kilohms. For example, it can be seen that a 1000:1 change in input signal amplitude causes a change as small as 2:1 in output level. This characteristic can be put to practical use in single-range bridge-balance detectors and signal-strength indicators. Voltage measurements can be made with an AC millivoltmeter.

When a sinewave input is applied to the circuit, the two diodes limit the output voltage swing to about 1.4 volts peak-to-peak by clipping the waveform. The output approximates a

TABLE 1
NONLINEAR AMPLIFIER PERFORMANCE

Millivolts (input, RMS)	R1 = 1K		R1 = 10K	
	V_{OUT} mV RMS	V_{GAIN}	V_{OUT} mV RMS	V_{GAIN}
1.0	110	×110	21	×21
10.0	330	×33	170	×17
100.0	450	×4.5	360	×3.6
1000.0	560	×0.56	470	×0.47
10,000.0	600	×0.07	560	×0.56

TABLE 2
CONSTANT – VOLUME AMPLIFIER PERFORMANCE

R1 = 100K		
Millivolts (input)	V_{OUT} (volts)	V_{GAIN}
500	2.85	×5
200	2.81	×14
100	2.79	×28
50	2.60	×52
20	2.03	×101
10	1.48	×148
5	0.89	×180
2	0.4	×200
1	0.2	×200
0.5	0.1	×200

Continued on page 93

DRAWING BOARD

continued from page 86

Running speaker cable throughout the house from a central location where I have all the audio equipment is certainly not a big deal from an electronic point of view, although keeping it hidden in the walls can be difficult. The complexity of the project was increased by a factor of ten when I was informed that everybody wanted a system that would allow different sources to be routed to different speakers at the same time—the cassette player to the kitchen, CDs to the bedroom, the TV to the den, and so on.

The easiest way to do this would be with a patch panel, but the thought of endless patch cable repairs wasn't too appealing. Besides, an all electronic router is a lot more elegant. My winter project now is now to build an easy-to-use audio router. Easy-to-use means it should have a minimum of controls and a display panel that shows exactly what audio is going where.

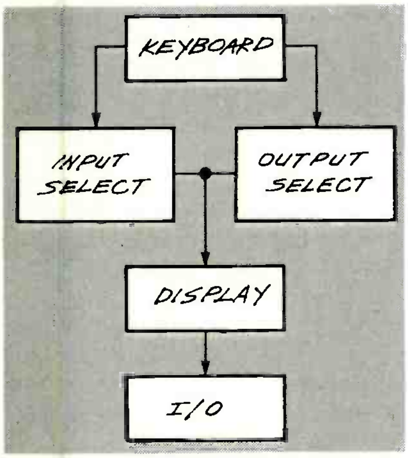


FIG. 3—AUDIO ROUTER BLOCK DIAGRAM. The keyboard is used to select the input and output channels.

Here's my list of design criteria:

1. The circuit shall accept eight stereo audio inputs (each input shall consist of a left and right channel).
2. The circuit shall have four stereo audio outputs (each output shall consist of a left and right channel).
3. The device shall display routing on LEDs.
4. There shall be a simple way to clear the inputs and outputs.

While there's no reason why I couldn't incorporate a power amplifier on each output channel, but for the moment I want to keep everything as simple as possible by dealing only with line-level signals. As we get into the design of the circuit, you'll see how easy it is to make changes.

Every circuit design starts with a block diagram, and that's what you'll find in Fig. 3. The keyboard selects the input and output channels. That information is sent to the display which I've specified in the design criteria. From that point on, the control signals are sent to the I/O sections where the actual audio routing will take place.

Before I get into the nitty gritty of the design, I want to explain how the device will be organized. The simplest way to set things up is on a grid system like that shown in Fig. 4. The inputs and outputs are arranged as intersecting lines, and the circuit I'm going to build makes the connections I want at the corresponding intersection of the desired column and row. Once the connection is made, the chosen input is routed to the chosen output. The display will indicate the status of the output channel.

Both the block diagram and the grid drawing show that there is one control line per channel. I'm mentioning this now because it reflects a decision I made about the parts I'll be using. All the audio switching will be done in the I/O section with analog switches—I'll be using CD4066B-CMOS ICs, ganging them together as DPST switches.

My decision about the design of the output stage affects the design of the whole circuit. The keyboard, for example, has to generate only a single-line address as opposed to an address with three or more lines if I were using binary addressing. This makes the design of the keyboard much simpler. Next month I'll explain the keyboard design. Ω

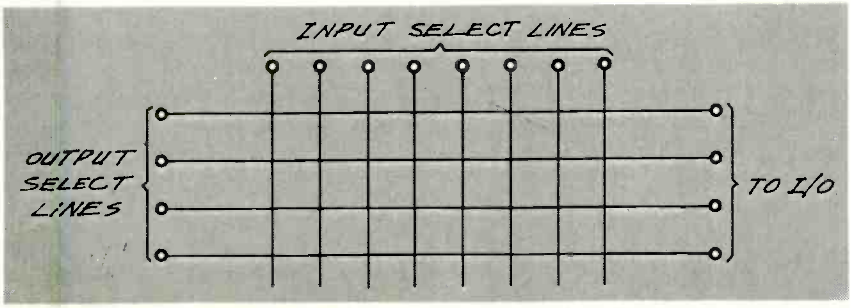


FIG. 4—THE DEVICE WILL BE ORGANIZED as a grid system. The inputs and outputs are arranged as intersecting lines.

"Well professor, how's the hologram experiment coming along?"

COMPUTER CONNECTIONS

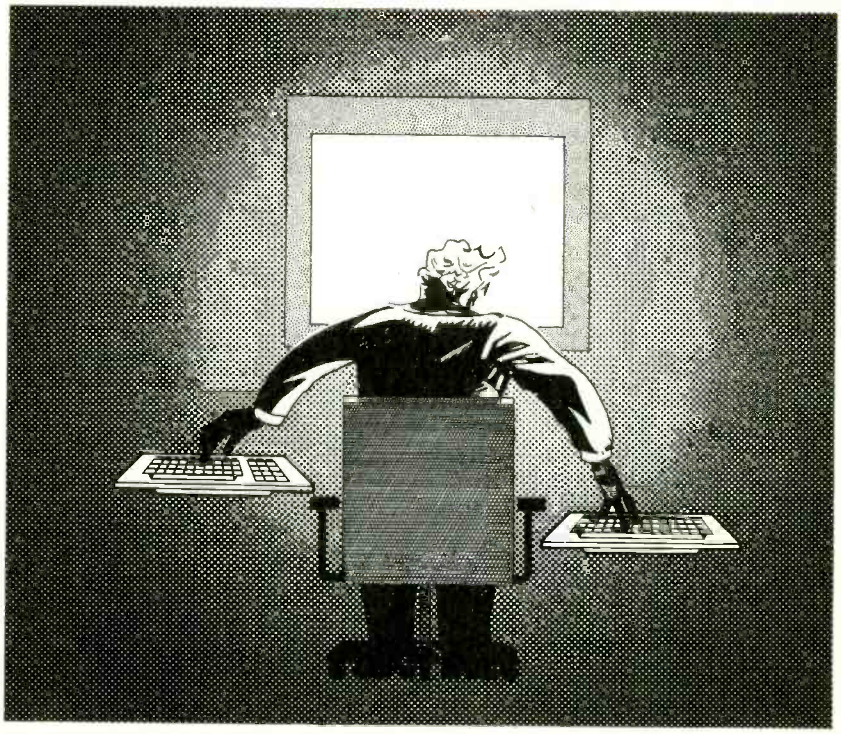
UberSoft uber alles.

JEFF HOLTZMAN

Deep underground lies the Command and Information Center, the hub of the most extensive computer network on Earth. This CIC differs from many corporate and military computing centers because it has direct, on-demand connectivity to many tens of millions of computers worldwide. The majority of these connections link private individuals to the CIC. A significant fraction of the remaining connections link corporate accounts located throughout the developed nations of the Earth.

The CIC is owned and operated by the richest, most powerful corporation on Earth: UberSoft. UberSoft is, in turn, owned and operated by one man: Charlie Haines. Haines started UberSoft on a shoestring; over a period of more than twenty years, a series of brilliant, opportunistic moves by Haines propelled UberSoft to its current position.

Today, total employment of the company exceeds that of any government on Earth save that of China. Haines pays his employees well, and rewards performance with shares in the company. Everyone works toward a common, well-articulated goal: UberSoft Uber Alles. The closer the company gets to that goal, the better the reward. Haines, nonetheless, always maintains a 51% share in the company.



THIS GUY PLAYED HIS CARDS RIGHT from the very beginning. He knows everything about everything.

UberSoft's early growth was achieved mostly by hard work and a healthy measure of intuition. Haines's intuition about directions in technology and fickle consumer tastes was legendary. By itself, that intuition was enough to build UberSoft into the mightiest corporation on Earth.

But Haines was not satisfied. He knew that his intuition could go only so far. He knew that at some point he would need a more direct means of measuring consumer tastes, something that could provide feedback in real time. Haines also knew that achieving such instantaneous feedback could be accomplished only by means of instantaneous real-time hookups to UberSoft's tens of millions of customers. That would entail a tremendous network infrastructure, on the order of that provided by the telephone companies. It would require tremendous advances in computer architecture, database design, transaction processing, and analysis software. It would also require extremely subtle software that would run on millions of UberSoft customer machines so as to provide UberSoft with the information it needed, but not alarm the owners of those machines that anything out of the ordinary was happening.

Haines knew that the scheme would be highly controversial. He knew that if even a single word ever leaked out about his plan, legal and ethical questions would be raised by the press, questions that could easily derail the plan, and possibly even UberSoft itself, questions that politicians and competitors would seize on to dismantle UberSoft and destroy Haines' empire.

Thus no one knew of the plan. That is, no one knew how all the pieces fit together. Haines instructed various marketing and technical groups throughout the company to work on various facets of the problem. Most people were content merely to be working for Haines and for UberSoft—content to be making good money; content to be working on interesting, challenging problems; and content to be astride a winner so far ahead of the competition that, in essence, there was no competition.

In his mind, Haines assembled a

AUDIO FILTERS

continued from page 64

square waveform, and it is rich in odd harmonics. If this waveform is amplified, it sounds like a clarinet.

Constant-volume amplifier

The nonlinear amplifier shown in Fig. 9 gives a near constant-amplitude output signal over a wide range of input signal levels, but it does this at the cost of introducing large signal distortion. Figure 10 is a schematic for a *constant-volume* or *constant-amplitude* amplifier that amplifies without distorting the signal. A self-adjusting, voltage-controlled linear network replaces the nonlinear element in the feedback loop of Fig. 9.

FET gate from the network consisting of D1, R5, R6 and C3. The FET functions as a resistance with a value of several hundred ohms. The voltage divider formed from R4 and Q1 causes slight negative feedback that is applied to the 741, so it provides high voltage gain.

By contrast, if a large signal is applied to the 741, its output is large, so a large negative bias is developed on the gate of FET Q1 from the D1, R5, C3 network. As a result, Q1 acts like a very high resistance. In this condition, the R4/Q1 divider applies large negative feedback to the 741, and it provides low voltage gain.

The overall effect of this response characteristic is that the mean level of the output signal is self-regulated at 1.5 to 2.85 volts over a 50:1 range of input

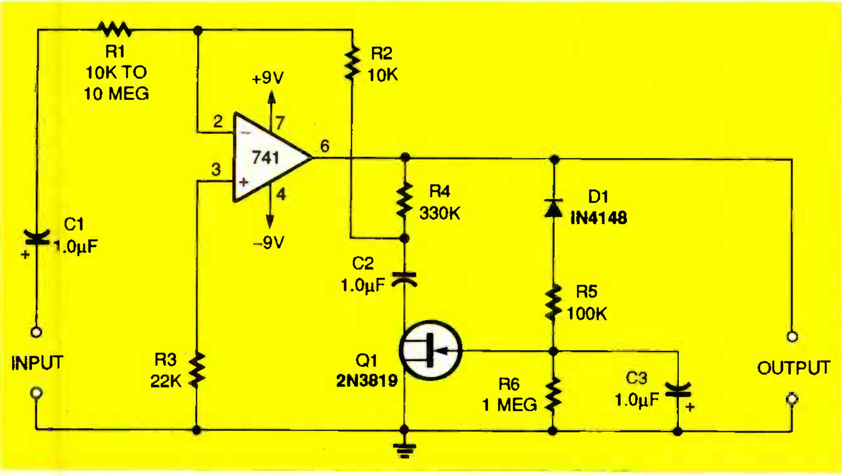


FIG. 10—CONSTANT-VOLUME amplifier that includes a JFET.

The operational amplifier is configured as an AC amplifier with its gain controlled by the ratio of the values of resistor R1 with respect to R2 and by the AC voltage divider formed by R4 in series with the internal impedance of Q1.

This FET functions as a voltage-controlled resistor. Its control voltage is obtained from the output of the operational amplifier with a network formed by diode D1 in series with resistor R5 and resistor R6 in parallel with capacitor C3.

When a small signal is applied to the 741, its output is small. Consequently, very little negative bias is developed on the

signal level. (This is equal to 500 to 10 millivolts.) It does this without generating audible signal distortion. The circuit's performance is summarized in Table 2.

The value of resistor R1 determines the sensitivity of the circuit. It is selected to accommodate the maximum input signal amplitude that the circuit is expected to handle. This is determined on a basis of 200 kilohms per RMS volt of input signal.

For example, to accommodate a maximum input of 50 volts, R1 should have a value of 10 megohms. Capacitor C3 determines the automatic gain control time constant of the circuit. Ω master plan that took more than a decade to put into practice. It involved insinuating UberSoft products at the every level of the computing hierarchy. It involved applications programs, operating systems, and network operating systems. It involved alliances with telecommunications providers (telephone and cable TV companies, and on-line service providers). It involved strategic influence over hardware designs ranging from CPUs to memory architectures to mass-storage devices to sound and video services.

Early efforts involved alliances. Subsequent efforts involved takeovers. Over time, UberSoft absorbed or destroyed every company with which it ever formed an alliance. Gradually, UberSoft grew from a supplier of programming languages and a few applications to a supplier of every element of hardware and software across all levels of the computing food chain, ranging from personal computers and software, to networking equipment and software, to wide-area communications systems, to content providers including a television network, a publishing conglomerate, and a Hollywood studio. UberSoft owned newspapers, television stations, production studios, rock bands, libraries, movie stars, directors, and entire multimedia production companies.

During the decade when all that was being built, Haines innocuously began building his personal mansion, home to his collection of expensive sports cars. To the public, the mansion was ostensibly a rich man's plaything, a technophile's dream home, replete with multimedia computers and communications systems in every room of the house. Unbeknownst to even Haines's closest associates, however, was a simultaneous subterranean construction effort, what we know now as the CIC, brilliantly hidden under the guise of being part of the mansion.

Several key pieces of Haines's plan kicked into place in late 1994, when UberSoft executed three strategic moves: 1) Launched its own on-line telecommunications service, 2) Made freely available software for accessing it, and 3) Swallowed up yet another competitor, a billion-dollar firm that wrote software for personal and small-business software: OutOfIt. OutOfIt had grown steadily from humble beginnings in a very Hainesian, yet more focused manner. The company held an unassailable position in its market segment. Hitherto, that segment had been one of Haines' few disappointments, but with the acquisition of OutOfIt, all the pieces were in place for UberSoft and Haines' next move.

In addition to being a brilliant business tactician and strategist, Haines was also brilliant technically. He did not know the detailed workings of every product sold by UberSoft, but it wasn't because he was incapable. In fact, as time passed, Haines knew progressively less and less about the internal workings of UberSoft products. Some thought he was losing interest. The truth was that his interests had evolved to a higher-level focus on systems, system architectures, and interoperability of systems. Again, that was all part of his master plan.

The war room

Deep underground lies the Command and Information Center, the hub of Haines' wide-area computer network. The CIC is laid out like a war room, with huge displays covering every square inch of wall space in a circular room with a diameter of 60 feet. Throughout the room are clusters of computers. One group serves as the hub of the on-line service network. Another functions as the primary repository for UberSoft's corporate data, including all technical, financial, and market information. Yet another serves clients of the former financial software company OutOfIt. Others link the CIC to UberSoft's telephone network, communications satellites, and production companies.

In the center of the CIC, raised above the myriad blinking lights and computer screens, rests a huge dais, on which sits a chair, something like a convoluted, high-tech dentist's chair. This chair is the center of Haines' universe. Its electronic tentacles spread out to cover vast portions of civilization. These tentacles pulse with information, the lifeblood of civilization today, information detailing every activity performed by every one of the tens of millions of computers connected to UberSoft's network.

Unbeknownst to his customers, indeed, to all but a select few of his employees, the software that connects individual customers to the network also serves as an on-demand two-way information pipe. Special hidden features of the software can be awakened remotely by the UberSoft network, automatically or on demand by whoever sits in the hot seat at the basin of the CIC.

Those hidden software features allow Haines to interrogate and view information on his customers' computers. He can, at any time, switch among any of millions of nodes in his network. He can view the contents of his customers' hard disks. He can read their E-mail. He can read their personal files. He can also read files of interest to UberSoft, files that can increase the company's already formidable business advantage.

Actually, Haines found that after the initial thrill, those millions of hard drives were pretty boring. Most of the data-collection effort was thenceforth carried out automatically, in the background, without anyone's noticing. Gradually, the data allowed Haines to develop market profiles of unprecedented scope and accuracy. Everything in his database could be sorted by age, race, income, location, education, and myriad other characteristics.

Questions

Is that scenario far-fetched, unrealistic? Not really. Much of what is described could be accomplished today—without a big, expensive "war room." Any computer user with an Internet connection and a little knowledge of network protocols could easily gain similar access to all sorts of corporate and private data.

Any telecommunications software—for example, the software you use to access CompuServe, America On-line, or Prodigy, or a generic program like Crosstalk or

Procomm, or a built-in program like the one that will appear in Windows 95 for the purpose of connecting to Microsoft's new on-line service with a single click—any such program could easily be adapted to transparently upload to the host all sorts of information about your system. And you.

That could include technical information, such as your CPU, hard disk size, or amount of memory, that would enable the provider to better tune its software to your needs. But it could also include any other data stored on your computer, or on any other computer to which your computer has access. In other words, not only is your personal and technical data at risk, but so is your company's.

Many people and corporations fear the possible effects of computer viruses. But who considers the possibility of a "Trojan Horse," a seemingly benign piece of software that could easily reveal your innermost secrets?

CD redux

My E-mail drew lots of interesting comments to my December column, in which I advocated a new kind of software documentation called Conceptual Documentation. Conceptual Documentation is the antithesis of the trivia promulgated by the "Dummies" books. It teaches you about the skeleton and the muscles so you can figure out how to walk, and maybe even run, all by yourself.

S. Fingerman, a software instructor, points out that "Unfortunately, a lot more people buy TV Guide than Electronics Now, and they still can't figure out how to use their VCRs." That's right. As I said, it's a social problem. As a society, we want easy answers. We don't want to think.

D. Wigginton, an IBM survivor, has a good analogy for the typical process of learning a new piece of software: "How obvious it is that having an overall floor plan of the house would make it so much easier to use effectively. Instead, we wander throughout our software as if we were playing some permutation of Myst, looking for clues and repeatedly drawing revised visual sketches in our minds of what the thing we're working with really is."

Last, T. Nichols, a self-described RF/microwave engineer with a PhD in electromagnetics, states that "What people tend to miss, in my experience, is that those 'highfalutin' concepts' may slow down the solution to their problem the first time around. But it will greatly speed up the solution to their problem the second and third and fourth. . . ."

Please feel free to send any comments to jkh@acm.org. Ω

WHAT'S NEWS

continued from page 4

data-communication and telecommunication segments that serve the computer and telecommunication industries. Protocol analyzers, Equipment that finds transmission problem, BERTs (bit error rate testers), and BLERTs (block error rate testers) will show rapid sales increases.

Hewlett-Packard continues to be the leading share holder in most product categories. Other major players include Anritsu, Tektronix, John Fluke, Marconi Instruments, Rhode & Schwarz, Network General, and Telecommunication Techniques.

Collision warning for cars

Three different kinds of automotive anti-collision systems have been announced so far—those based on sensors which respond to reflected radio frequency, microwaves and infrared energy. Their purpose is to warn drivers about the presence of vehicles in their "blind zones" when they are about to change lanes.The manufacturers of these systems are competing to develop systems that will be accepted as standards by auto manufacturers for installation on automobiles.

So far no automo manufacturer has announced a date when any anti-collision system will be installed, either as standard or optional equipment on automobiles. This leaves an opportunity for a lucrative automotive aftermarket for independent manufacturers of the systems. Car owners would be able to buy one of the systems available that they could install or let the seller install, as is now done with add-on acessories.

Statistics from the U.S. Department of Transportation reveal that 13% to 15% of all vehicle collisions occur as a result of the drivers' inability to see other vehicles in blind spots as they change lanes. However, some automotive experts believe that number is inflated and the true figure is nearer to 7%.

The latest introduction in the anti-collision sweepstakes is the SideMinder system, based on infrared and LED technology. Developed by Autosense, Denver, Co., the system includes infrared sensors and detectors and an LED display developed by Siemens Optoelectronics Div., Cupertino, Calif.

Autosense expects to make SideMinder systems available in production quantities to auto manufacturers for less than $50 each. This figure compares with the $100 to $500 estimates of systems costs for systems based on other technologies.

SideMinder is activated when the vehicle's turn signal is activated. Infrared sensor modules, located behind the host vehicle's tail-light lens assemblies, monitor "blind" spots on both sides of the car for a distance of up to 15 feet.

When the driver wants to change lanes, he activates the turn signal which, in turn, activates the system. Infrared energy from the module that is reflected from nearby vehicles activates a circuit in the host vehicle to lights LED lamps located in either the passenger- or driver-side rear-view mirrors if a vehicle is one of the blind spots. Detection occurs in a fraction of a second.

Cars equipped with prototype SideMinders are now being tested in the United States and Europe. Autosense reports that the systems could be offered as optional equipment on passenger cars and vans within the next five year.

Recently the Delco Electronics Corporation announced the development of a car radar system that would accomplish the same objective. Delco, a division of General Motors, said it is unlikely that the system will be offered as an option on cars until about 1998 or 1999. However, it is expected to have a version for trucks available this year.

Delco has had its collision avoidance systems on school buses for a year to warn bus drivers of nearby objects. Nissan Motor Company developed a laser-based warning systems for trucks three years ago, but has no plans to put them in automobiles.

Delco's radar system for trucks has four-inch square transceivers mounted on the sides of the truck's cargo box. When the driver signals a lane change, the system is activated. Microwaves emitted by the transceivers reflect from any cars that are in the driver's blind spots, and returned signals are detected. An audible signal sounds and lights mounted on the sideview mirrors flash. This system also has a range of 12 to 15 feet.

TRW Inc. has also developed a microwave radar system collision avoidance system but Amerigon Inc., Monrovia Calif., has developed a pulsed radio-frequency system. Both Chrysler Corporation and Ford Motor Company are reported to be developing their own collision avoidance systems. Ω

VIDEO NEWS

continued from page 6

movies are available in the Video CD format.

• **Balance of power.** At least two hardware manufacturers and one movie studio are believed to wield the greatest influence over the final selection—if, indeed, a single system is chosen. Matsushita Electronic (Panasonic), the world's largest consumer-electronics manufacturer, originally was believed to be in the Sony–Philips camp, but released a brief statement saying that it "considers it desirable that a uniform standard eventually be selected ... [to] meet the needs of the software industry, avoid confusion among consumers, and increase the availability of software." Matsushita said that it was "conducting its own study of the matter."

The other major hardware power holding the balance is Thomson Consumer Electronics, maker of RCA and GE TV sets, which holds the biggest share of the U.S. market and is also a power in Europe. Among the Hollywood movie companies, Disney could be the biggest influence, since it is unaffiliated with a hardware manufacturer. Matsushita owns MCA, parent of Universal Pictures, while Sony owns the former Columbia Pictures, and, of course, Toshiba is allied with Time Warner, parent of Warner Brothers. Ω

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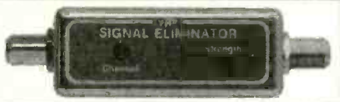

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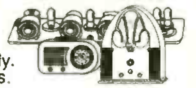

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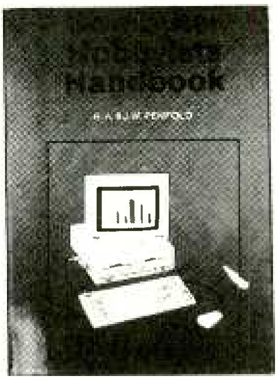

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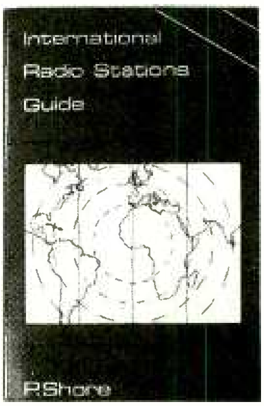

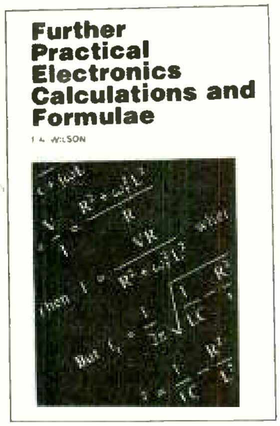

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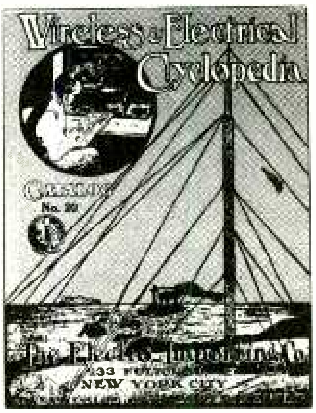

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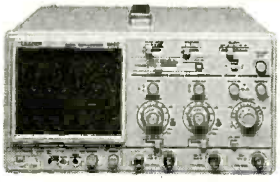

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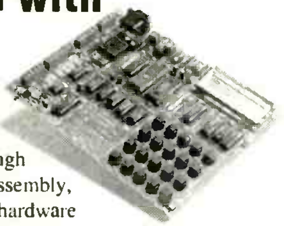

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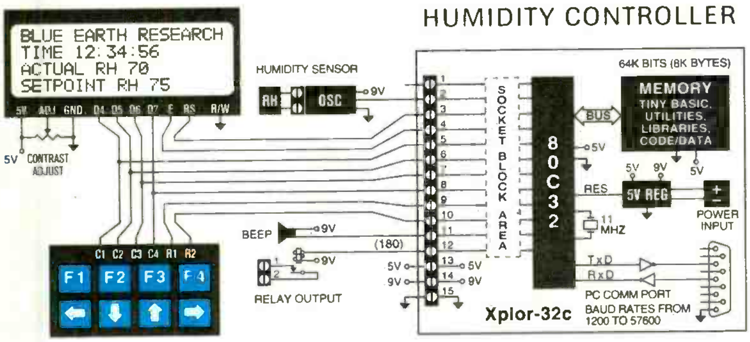

ALL YOU NEED IS A PC and a Terminal Program
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No Other Programming Equipment Required!

```
10  CALL 8132                            (LIBRARY FUNC: Initialize LCD)
20  ONTIME 200                           (Initialize 1 second interrupt)
30  PRINT "BLUE EARTH RESEARCH" ;        (Display sign-on message)

40  PRINT " \\ ACTUAL RH " ; FREQ 0 ;    (Display actual sensor frequency)
50  PRINT " \\\ SETPOINT RH " ; S ;      (Display desired setpoint value)

60  CALL 8140                            (LIBRARY FUNC: Get keypad input)
70  IF DBY 27=6 THEN S=S - 1             (Decrement setpoint if down arrow)
80  IF DBY 27=7 THEN S=S + 1             (Increment setpoint if up arrow)

100 IF FREQ 0<S THEN BIT 180=1           (If actual < setpoint then relay on)
110 IF FREQ 0>S THEN BIT 180=0           (If actual > setpoint then relay off)
120 GOTO 40                              (Loop back to repeat program)

200 PRINT " \TIME " ; DBY 51 ; " : " ;   (This 1 second interrupt routine)
210 PRINT DBY 50; " : " ; DBY 49 ; : IRET ( refreshes LCD with current time. )
```

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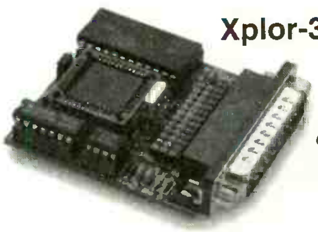

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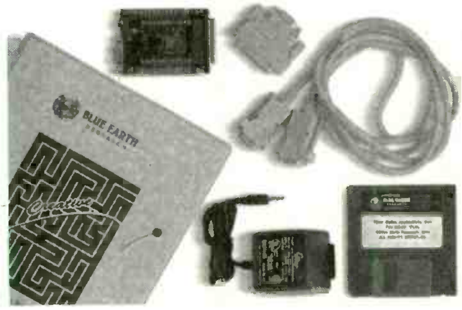

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LM331	4.79
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LM337K	3.29
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7806T	.59
7808T	.59
7810T	.59
7812T	.59
7815T	.59
7824T	.59
7805K	1.79
7812K	1.79
7815K	1.79
7824K	1.79
78M05	.59
78M08	.59
78M12	.59
78M15	.59
78M24	.59
UA78S40	2.39

Negative Output

79L05	.45
79L12	.50
79L15	.55
7905T	.59
7906T	.59
7908T	.59
7910T	.59
7912T	.59
7915T	.59
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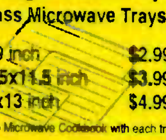

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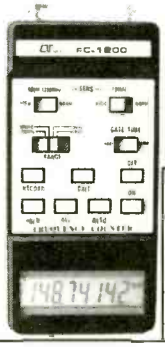

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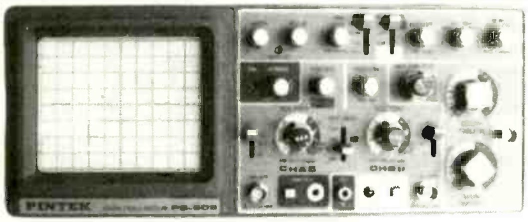

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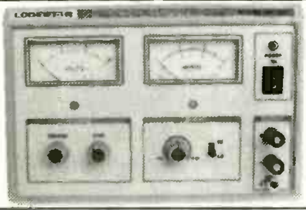

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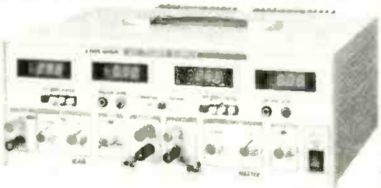

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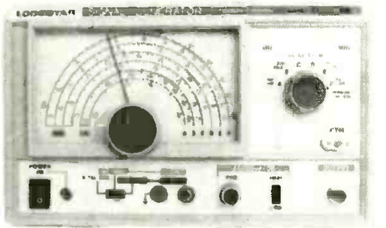

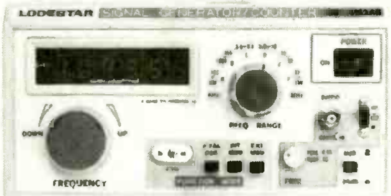

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RF Output 100mVrms to 35 MHz
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Audio output 1 kHz, 1 Vrms

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Generates RF signal same as SG-4160B
6 digit frequency counter 1Hz - 150 MHz for internal and external source Sensitivity <50mV

AUDIO GENERATOR AG-2601A $119.00

10Hz - 1MHz in 5 ranges
Output: 0-8Vrms sinewave
0-10Vp-p squarewave
Synchronization: ±3% of oscillation frequency per Vrms
Output distortion:
0.05% 500Hz - 50kHz
0.5 % 50Hz - 500kHz
Output impedance: 600 ohm

AUDIO GEN./COUNTER AG-2603AD $229.95

Generates audio signal same as AG-2601A
6 digit frequency counter 1Hz-150MHz for internal and external sources Sensitivity <50mV

FUNCTION GENERATOR FG-2100A $169.95

0.2 Hz -2 MHz in 7 ranges
Sine, square, triangle, pulse and ramp
Output: 5mV-20Vp-p
1% distortion, DC offset ± 10V
VCF: 0-10V control frequency to 1000:1

FUNCTION GEN/COUNTER FG-2102AD $229.95

Generates signal same as FG-2100A
Frequency counter 4 digits
Feature TTL and CMOS output

SWEEP FUNCTION GEN./COUNTER $329.95

0.5Hz to 5 MHz in 7 ranges
Sweep: Linear 10:1/Log 10:1 20ms to 2s
AM Modulation
Gated Burst, Voltage Control Generator
Generator Control Voltage & 6 digit counter
1Hz-10MHz for internal & external sources

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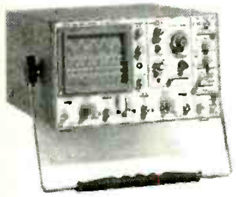
100 MHz Cursor Readout Scope 4 ch, 8 traces OS-6101 $1,499.95

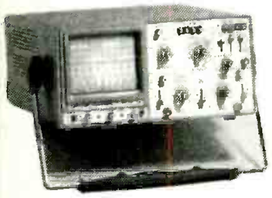
* 4 independent channels, 8 traces
* Time /Voltage cursor measurement
* ALT triggering function for 4 ch.
* Sweeps to 2ns/div, Delayed Sweep
* TV Sync., Ch. 1 output, Z-axis input
* 2 probes(x1, x10)

100 MHz Scope, 4ch. 8 traces Best value all purpose scope OS-6100B $1,329.95



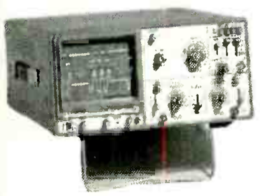
* 4 channels, 8 traces
* High sensitivity 500µV/div
* Sweeps to 2ns/div, Delayed sweep
* 20 kV accelerating voltage
* TV sync., Z-axis input
* A and B gate output
* Best price 100 MHz scope
* 2 probes(x1, x10)

50 MHz Triggering Oscilloscope OS-653 $699.95



* Dual Channel
* Hold Off Function
* Delayed Sweep
* Built-in Delay Line
* TV Sync
* ALT Triggering
* High sensitivity 1 mV/div
* Trigger level lock function
* Z-axis input, CH1 output
* 2 probes(x1, x10)

20 MHz Oscilloscope OS-622B $344.95



* Dual trace, X-Y operation
* TV Sync., Z-axis input,CH 1 output
* High sensitivity 1 mV/div
* Trigger level lock
* 2 probes (x1, x10)

OS-645B - 40 MHz Cursor readout .... $ 734.95
OS-625B - 20 MHz Cursor readout .... $ 549.95
OS-623B - 20 MHz w/Delayed Sweep .... $ 449.95
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PS-1850 : (0-18V, 0-5A) $219.95
PS-1850D : Digital Display $244.95
PS-3030 : (0-30V, 0-3A) $224.95
PS-3030D : Digital display $254.95
PS-6010 : (0-60V, 0-1A) $209.95

PR-1810H : (0-18V, 0-10A) $349.95
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PR-6030 : (0-60V, 0-3A) $299.95
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* Continuous/dynamic load can be selected
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* Auto tracking (PPT series), IEEE-488.2 and SCPI compatible command set (optional)

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PPS-3635G: (0-36V, 0-3.5A) $1099.95
PPS-6020G: (0-60V, 0-2A) $1099.95
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* Three Instruments in one: Function generator, Pulse generator & Frequency counter.
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* Variable DC offset control

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* 0.02Hz-2MHz (No Counter) $189.95

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* 8 Function, AC/DC voltage, AC/DC current, resistance
* Built-in C meter, diode test and audible continuity check
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* 0.5% basic accuracy

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* Measures ACV to 50 kHz $339.95

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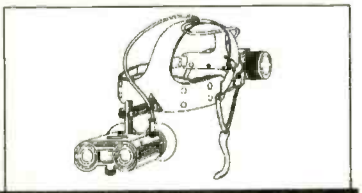


HEAD MOUNTED IR BINOCULARS

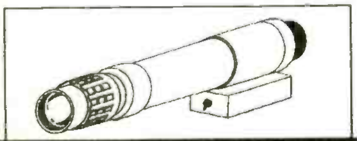
These lightweight USSR made binoculars will produce good vision with 1/4 moonlight illumination, but can also be IR assisted at lower light levels: Work well with our $11 IR filter. Powered by 4 AAA batteries (6V), 1 X magnification, angle of vision 28 deg., focuses from 2' to infinity.

$380

VISIBLE LASER DIODE KIT

Just the basics: A 5mW / 670nM visible laser diode plus a collimating lens, plus an APC driver kit UNBELIEVABLE PRICE:

$26

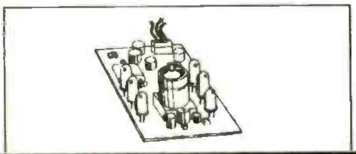


INTENSIFIED NIGHT VIEWER KIT

See in the dark! Make your own night scope that will produce good vision in sub-starlight illumination! We supply a three stage fibre optically coupled image intensifier tube, EHT power supply kit, and sufficient plastics to make a monocular scope. The three tubes are supplied already wired and bonded together.

**$200 for the 25mm version
$280 for the 40mm version**

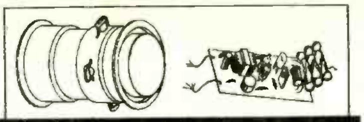
We can also supply the lens (100mm f2: **$50**) and the eyepiece (**$12**) which would be everything that is necessary to make an incredible viewer!



CCD CAMERA

Monochrome CCD Camera which is totally assembled on a small PCB and includes an Auto Iris lens. 9-12V DC operation. It can work with illumination of as little as 0.1Lux, and is IR responsive: Can be used in total darkness with Infra Red Illumination. A suitable illuminator is our HIGH POWER LED IR ILLUMINATOR kit. Overall dimensions of camera are 24 X 46 X 70mm and it weighs less than 40 grams! Can be connected to any standard monitor or the video input on a Video cassette recorder: EIA (US - NTSC) compatible.

$145



FIBRE OPTIC TUBES

These US made tubes are "pulls" from equipment, in excellent condition. Have 25 / 40 mm diameter, fibre - optically coupled input and output windows. The 25mm tube has an overall diameter of 57mm and is 60 mm long, the 40mm tube has an overall diameter of 80mm and is 92mm long. The gain of these is such that they would produce a good image in approximately 1/2 moon illumination, when used with suitable "fast" lens, but they can also be IR assisted to see in total darkness. Our $11 IR filter is suitable for use with these tubes. Suitable for low light video preamplifiers, wild life observation, etc. Each of the tubes is supplied with an 9V - EHT power supply kit. REDUCED PRICES:

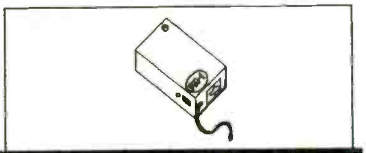
$75 .....For the 25mm intensifier tube and supply kit.
$110 .....For the 40mm intensifier tube and supply kit.

We also have a good supply of the same tubes that may have a blemish which is not in the central viewing area!: Satisfaction guaranteed! !!ON SPECIAL!! $40 .....For a blemished 25 or 40mm (Specify preference) image intensifier tube and supply kit. Matching good quality eyepiece lens only, ***$6 Extra! That's almost a complete night viewer kit for $46.***

IR TUBE AND SUPPLY

A tube and supply combination that can be used as the basis of making a very sensitive IR responsive viewer. The tube employed is probably the most sensitive IR responsive tube we ever supplied, and the EHT supply kit enables the tube to be operated from a small 9V battery. Basic instructions provided.

$80



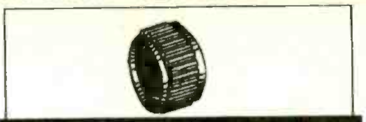
MINIATURE FM TRANSMITTER

Not a kit, but a very small ready made self contained FM transmitter enclosed in a small black metal case. It is powered by a single small 1.5V silver oxide battery, and has an inbuilt electret microphone. SPECIFICATIONS: Tuning range: 88 - 108MHz, Antenna: Wire antenna - attached, Microphone: Electret condenser, Battery: One1.5V silver oxide LR44 / G13, Battery life: 60 hours, Weight: 15g, Dimensions: 1.3" X 0.9" X 0.4".

$25

SECOND GENERATION TUBES

WE SHOULD HAVE A REGULAR SUPPLY OF SOME NEW USSR MADE 18mm 2'ND. GEN. FIBRE OPTICALLY COUPLED IMAGE INTENSIFIER TUBES @ APPROX. **$500.**



INFRA RED FILTER

Very high quality IR filter and a RUBBER lens cover that would fit over most torches including MAGLITE's, and convert them to a good source of IR. Suitable for use with passive and active viewers.

$11

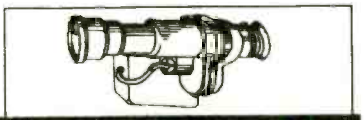
For the filter and the rubber lens cover.

GLASS PRISMS

Precision 90 deg. glass prisms with a mirrored backing. We have a limited quantity of these prisms

$10
For the smaller prism: Approximately 18 X 18 X 24 X 64mm.

$20
For the larger prism: Approximately 18 X 18 X 24 X 127mm.



PASSIVE NIGHT VIEWER KIT

See Electronics Now Oct. 94. This kit is based on a BRAND NEW passive night vision scope, which is completely assembled and has an EHT coaxial cable connected. This assembly employs a high gain passive tube which is made in Russia. It has a very high luminous gain, and the resultant viewer will produce useful pictures with starlight illumination. It needs an EHT power supply to make it functional, and we supply a suitable supply and it's casing in kit form.

$220

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SINGLE CHANNEL UHF REMOTE CONTROL KIT: One transmitter and one receiver: $32 additional transmitter $11
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Kit $19.95
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2N3055	.69
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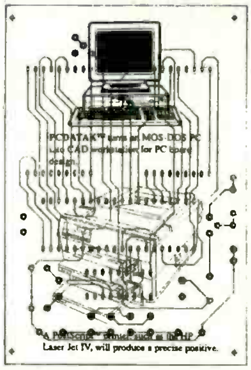

The NEW PCDATAK™ software lets you create PC boards ranging from prototypes to hobby projects, and on a par with the Pro's. You may do the complete printed circuit board layout artwork on your own PC; at a fraction of the cost of other programs. Print the layout on any PostScript™ compatible printer, either on regular paper to be photographed for a positive or negative, or on clear film to be used directly as a positive with other Datak products.

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PCDATAK™ is supplied on one 3.5" diskette with a quick start manual. The full user's manual is larger and must be printed by the user (dot matrix printer ok); approximately 75 pages in length.

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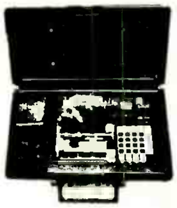

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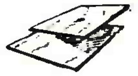

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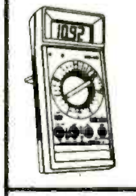

DIGITAL LCR METER measures inductance, capacitance and resistance. At Last! An LCR meter that everyone can afford. Now you can measure coils, transformers, chokes from 1µH to 200H. Capacitors from .1 pfd to 200 mfd and resistors from .1 ohms to 20 meg ohms. All in one handheld instrument.

MODEL LCR-1801 .... $119.95

SIGNAL INJECTOR/TRACER KIT

This handy tester is both a signal generator and receiver. As a generator use it to check out an amplifier, stage by stage. Also tests AM radio IF and RF stages. As a receiver you can pin point where a defective part exists. Will transmit and receive simultaneously.

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We cannot bill for classified ads. Payment in full must accompany your order. We do permit repeat ad or multiple ads in the same issue, but in all cases, full payment must accompany your order.

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Our classified ad rate is $1.25 per word. Minimum charge is $18.75 per ad per insertion (15 words). Any words that you want set in bold or caps are 20¢ each extra. Bold caps are 40¢ each extra. Indicate bold words by underlining. Words normally written in all caps and accepted abbreviations are not charged as all-caps words. State abbreviations must be Post Office 2-letter abbreviations. A phone number is one word.

CONTENT

All classified advertising in the **Electronic Shopper** is limited to electronics items only. All ads are subject to the publisher's approval. We reserve the right to reject or edit all ads.

DEADLINES

Ads received by our closing date will run in the next issue. For example, ads received by April 1 will appear in the July,1995 issue that is on sale in June 1. Shopper ads will appear Jan., Mar., May etc. No cancellations permitted after the closing date. No copy changes can be made after we have typeset your ad. NO REFUNDS, advertising credit only. No phone orders.

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Send your ads with payment to:
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100 — Antique Electronics	270 — Computer Equipment Wanted	450 — Ham Gear Wanted	630 — Repairs-Services
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13 - $18.75	14 - $18.75	15 - $18.75	16 - $20.00
17 - $21.25	18 - $22.50	19 - $23.75	20 - $25.00
21 - $26.25	22 - $27.50	23 - $28.75	24 - $30.00
25 - $31.25	26 - $32.50	27 - $33.75	28 - $35.00
29 - $36.25	30 - $37.50	31 - $38.75	32 - $40.00
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37 - $46.25	38 - $47.50	39 - $48.75	40 - $50.00

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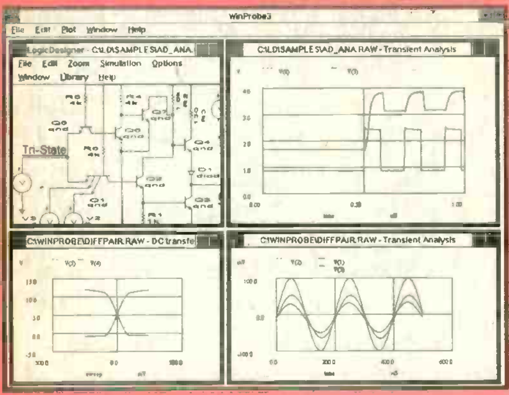

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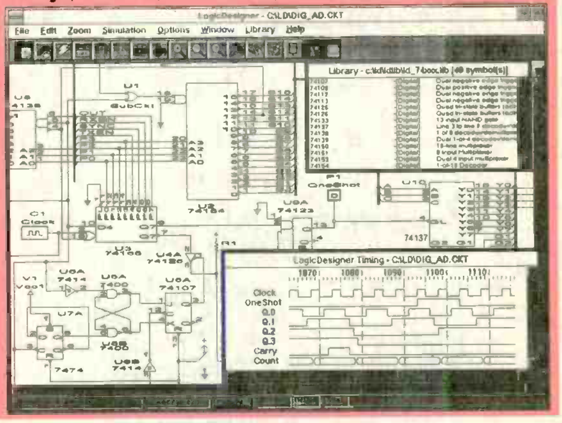

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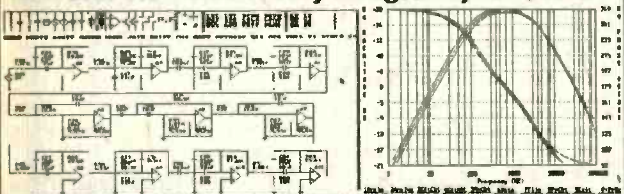

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20 character x 16 line capability.

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Mfr: Toshiba TLX-1013-EO.
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5V power required • Built in C-MOS LCD driver & controller • Easy "Microprocessor" interface • 98 ASCII character generator • *Certain models are backlit, call for more info.*

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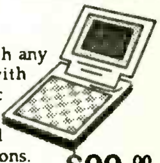
Proxim — Spread Spectrum RF Modem $99.00

The Proxlink is a small communication device that replaces the use of an RS-232 cable hook-up with wireless (Radio Frequency) technology. Each module combines the functions of an RS-232 compatible modem (or any other RS-232 device) and a transmitter/receiver operating in the 902-928 MHz band. Indoor range of up to 500 feet possible using standard 1/4 wave antenna. Units support data rates up to 19.2 KBaud (full duplex) and use multiple channels to allow for non-interfering overlapping systems. Message format is 8 data bits, no parity, and 1 stop bit. Each unit requires 5 VDC supply at a maximum of 230 mA. A wide variety of configurations can be accommodated with parameters stored in non-volatile memory (EEPROM). Configuration changes are supported by menu driven, on-board software. Installation schematics and application details are available. Original cost on these units is around $600.

Portable Micro Terminal



Flip up LCD display (9-16 VDC) • Can communicate with any computer having RS 232 port • Can communicate with another Microterminal • Use by itself as electronic notebook • Onboard microprocessor, data RAM (32K) and Video RAM (64K) • Complex built in diagnostics and set up capabilities. • Original intention for POS applications. • display size 40x16 (256 x 128 pixels.) Dimensions: 6.3" W, 11"L, 2"H. (With LCD up height is 7.1")

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Includes: • 286-12Mhz CPU (1 wait state) • Built in IDE & floppy controller • 80287 math coprocessor socket • FAST! on board SVGA with 256K RAM • 2 serial ports, 1 printer port, mouse port • EMS-LIM ver 4.0 memory & shadow RAM support • Up to 8 mb memory (256K or 1 Mb SIMMS) • Comes with 0K on board • On board speaker • REAL TIME CLOCK • Phoenix BIOS • Note: There is one long non standard bus connector on board

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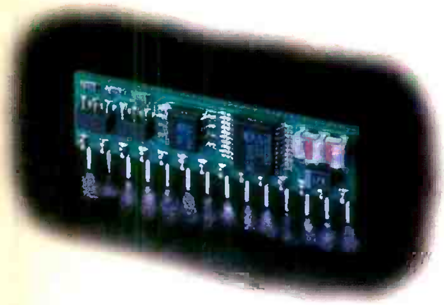
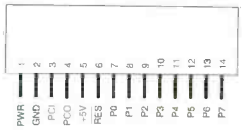


BASIC Stamp I Module (BS1-IC)
8 general-purpose I/O lines
256-byte program space (100 instructions)
4-MHz clock (2400 baud serial, etc.)
$29, $39 with carrier board*



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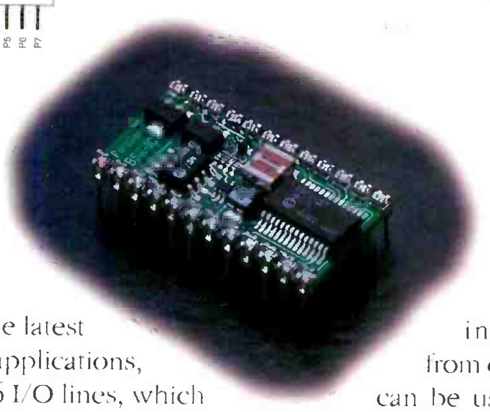
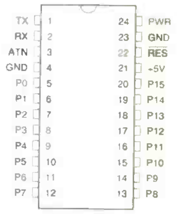
2048-byte program space (600 instructions)
20-MHz clock (9600 baud serial, etc.)
$49, $59 with carrier board*





They're here! These new BASIC Stamp modules are the latest in BASIC Stamp computers. These modules are perfect for numerous applications, from controlling model trains to monitoring factory sensors. They have 8 or 16 I/O lines, which can be used for a variety of digital and analog purposes. And like the original BASIC Stamp, these modules are programmed in BASIC. Our special "PBASIC" language includes familiar instructions, such as GOTO, FOR...NEXT, and IF...THEN, as well as SBC instructions for serial I/O, pulse measurement, and button debounce. In the new BS2-IC, there are even instructions for interfacing to popular devices from other companies, such as the Dallas Semiconductor "Time-In-a-Can" real-time clock.

**Carrier board provides battery clips, prototype area, and PC connector.*

The BASIC Stamp Programming Package contains everything you need to program Stamps using your PC. The package includes our editor software, programming cables, manuals, application notes, and free technical support. The package is available for $99; Stamps must be purchased separately.

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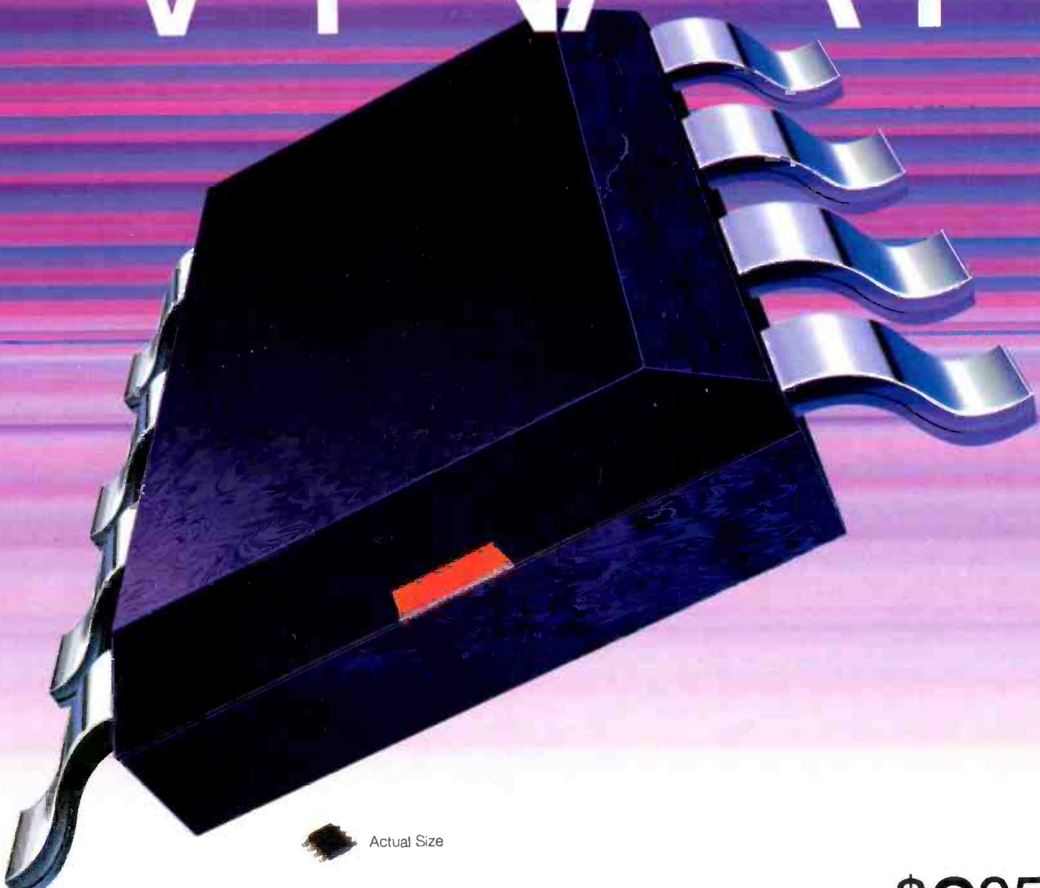
CIRCLE 195 ON FREE INFORMATION CARD

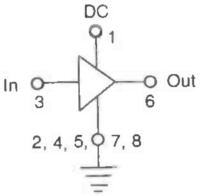
VNA!



Actual Size

VNA Amplifiers +17.5dBm, 0.5to2.5GHz only $2.95 (1000 qty.)

Very New Amplifiers...at a very affordable price, from Mini-Circuits! Yes, VNA-25 RF amplifiers are very small, yet incredibly powerful (+17.5dBm typ. output at 1dB compression). The SOIC-8 pin surface mount units operate directly from a +3V to +5V single DC supply with 18dB typ. gain and cover the popular 0.50-2.50GHz wireless band. These units are very easy to use because all capacitors are internal and RF/DC connections are separate, eliminating the need for both external coupling capacitors and an RF choke. You can buy these very new amplifiers for the low price of just $2.95 ea., qty.1000. Development qty.10, only $4.95ea.! So, call Mini-Circuits today for immediate off-the-shelf availability and guaranteed 1 week shipment.



Freq.(GHz)	.5-.8	.8-1.0	1.0-2.0	2.0-2.5
Gain (dB) typ.	14.0	17.0	18.0	16.0
Max. Output (dBm) @1dB Comp. typ.	+18.0	+18.5	+17.5	+17.0
I P 3rd Order (dBm) typ.	+27	+27	+27	+27
VSWR Output typ.	1.5:1	1.7:1	1.7:1	1.5:1
VSWR Input typ.	6.4:1	2.8:1	2.0:1	1.4:1

DC Power.: +5.0V for specified performance.
Current,(mA): 85typ., 105 max.
Thermal Resistance, Junction-to-case: 125° C/W
Price ($) ea. : 2.95 (qty. 1000), 4.95 (qty. 10).

- •All specs at 25°C (case temp. 35°).
- •Available in Tape and Reel.
- •MTTF at 150°C max. junction temp.: 3×10^7 hrs.typ. "Case" is defined as mounting surface of leads.

Mini-Circuits...we're redefining what VALUE is all about!

Mini-Circuits®

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For detailed specs on all Mini-Circuits products refer to • THOMAS REGISTER Vol. 23 • MICROWAVES PRODUCTS DIRECTORY • EEM • MINI-CIRCUITS' 740- pg. HANDBOOK.

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F 180 Rev Orig

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